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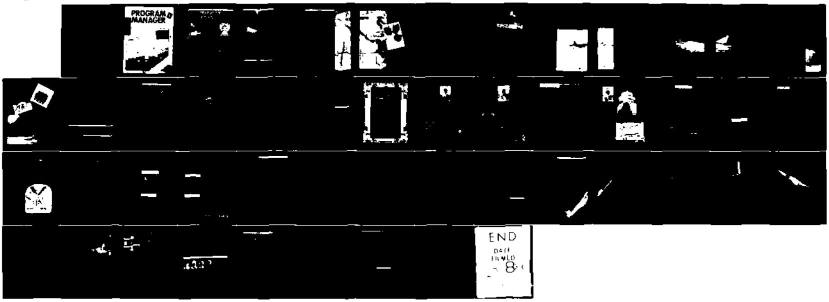

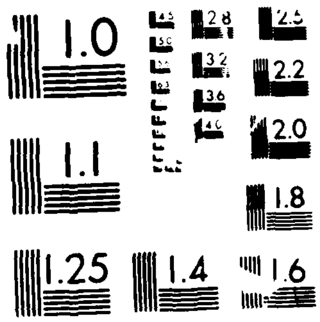

MICROCOPY RESOLUTION TEST CHART

PROGRAM MANAGER

November-December 1987

INSIDE:
THE PEOPLE'S
REPUBLIC OF CHINA

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PROGRAM MANAGER

JOURNAL OF THE DEFENSE SYSTEMS

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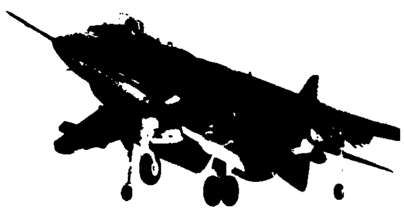
Vol. XVI, No. 6
DSMC 81
November-December
1987

MANAGEMENT COLLEGE

Cover: AV-8 Harrier.
Cover background: Canvas, rods, tacks and rope—details from Wright Brothers' first plane on display at Smithsonian Institution, Washington, D.C.



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Program Manager (ISSN 0199-7114) is published bimonthly by the Defense Systems Management College, Fort Belvoir, VA 22060-5426. Non-government employees and organizations may subscribe at $7.50 annually through the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Second class postage paid at Fort Belvoir, VA.

POSTMASTER: Send address changes to *Program Manager*, Defense Systems Management College, Fort Belvoir, VA 22060-5426

DESIGN

A PROGRAM MANAGER'S GUIDE TO PRODUCING NUCLEAR-SURVIVABLE SYSTEMS

Lieutenant Commander Robert J. Ross, USN
Dr. C. Stuart Kelley

Achieving nuclear survivability requires a system's approach; as such, it must be incorporated during all phases of acquisition, starting as early as possible.

What is Nuclear Survivability?

No system can be designed to survive a direct nuclear detonation. However, if you design your system properly it can survive the nuclear environment created when nuclear weapons detonate some distance away. The exact survival distance depends on the yield and height of detonation of the weapon, the design of your system, and the tactical employment of your system.

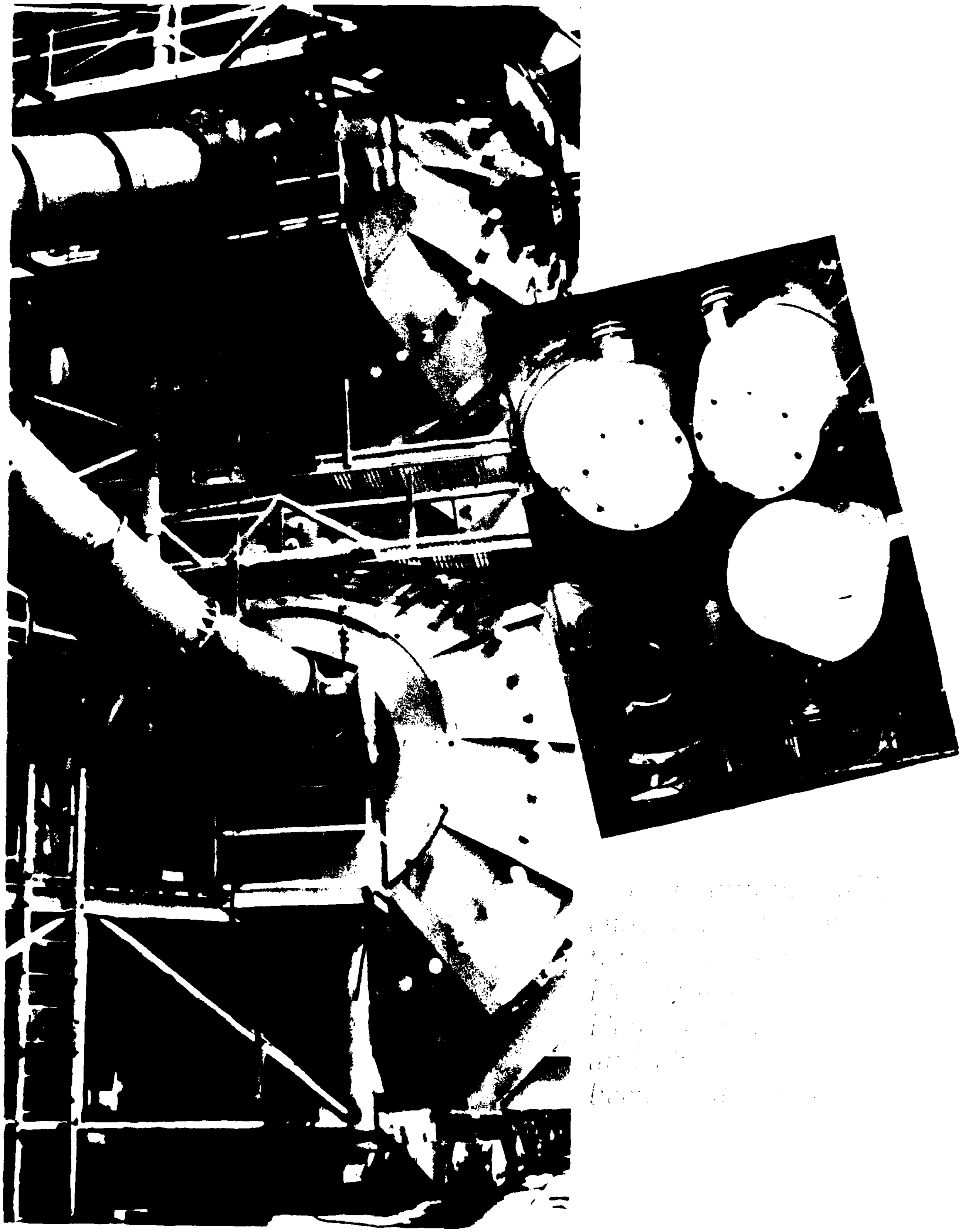
Program managers control acquisition of systems that may be required to survive in a nuclear environment. This article discusses DOD military and service nuclear survivability requirements, recommends actions for program managers, identifies resources supporting nuclear survivability efforts.

You will encounter two terms again and again throughout the life cycle of your system.

Nuclear Survivability. The capability of a system, or a subsystem to survive in a nuclear environment and to be able to accomplish its mission. Nuclear survivability can be achieved by a number of methods, ranging from proliferation to nuclear hardness.[1]

Nuclear Hardness. The physical attributes of the system or a component of that system that allows survivability in a given nuclear weapon environment. Nuclear hardness is achieved through design specifications and is verified by one or more test and analysis techniques.[2]

The nuclear survivability of your system is determined by the total combination of doctrine, organization, procedures, training, operational tactics, redundancy, proliferation, and (if required) nuclear hardening. Such tactics maneuverability, threat avoidance, and standoff can provide adequate means of nuclear survivability, and may (but usually do not) negate the requirement to harden a system's design. All systems have some inherent nuclear hardness. This inherent hardness may be adequate. If not, the ability of your system to withstand exposure to nuclear weapon effects must be increased through design.



The degree or level of nuclear survivability to be integrated into a system's design is based on the required operational effectiveness and survivability characteristics of the system, and are normally specified as "Nuclear Hardness Criteria." These criteria are used in developing design requirements. Nuclear hardness criteria are usually specified for each type of nuclear weapon effect: blast, shock, thermal, radiation, electromagnetic pulse (EMP), etc. For example, criteria for your system may require it to survive a 6 psi peak static overpressure, a 70 cal/cm² thermal dose, and high-altitude EMP. Once the nuclear hardness criteria are formally established, they are documented in the System (or Top Level) Specification and then are allocated down into the Developmental Specifications written for each of the system's Configuration Items.

A key point is that nuclear survivability is no different from any other performance capability such as accuracy, range, speed, etc. Since Nuclear Survivability falls within the function of performance, you should manage it as a required operational capability.

Why Build a Nuclear-Survivable System?

> It is DOD policy that nuclear survivability and hardness features shall be included in the design, acquisition, and operation of major and non-major systems that must perform critical missions in nuclear conflicts.[3]

This policy was developed because the primary strategy for ensuring the security of the United States is the continued deterrence of nuclear war. The acquisition of enduring, nuclear-survivable systems enhances the deterrent value of our forces by increasing an adversary's uncertainty about the effectiveness of its nuclear attack. In the event that deterrence fails and nuclear weapons are employed against the United States, deployment of enduring, nuclear-survivable systems ensures that our forces will have the military hardware and software necessary to perform critical wartime missions.

What Are DOD Nuclear Survivability Requirements?

To maintain viable, enduring deterrent forces, certain Department of Defense Instructions and Directives have been established. The DOD Instruction 4245.4, "Acquisition of Nuclear-Survivable Systems," is the central DOD document providing nuclear survivability policy. The DOD series 5000 Acquisition Instructions and Directives[4,5,6,7] and Service Regulations and Instructions[8,9,10] have been revised or created to address nuclear survivability requirements. For example:

DOD Instruction 5000.2, "Major System Acquisition Procedures," lists nuclear and chemical hardness, survivability, and endurance as principles to consider when planning major system acquisitions. This Instruction also requires you to "describe nuclear and non-nuclear (including chemical) survivability and endurance shortfalls that may impair mission performance in the proposed system, and indicate constraints that preclude satisfactory performance in response to the mission need."

The DOD Directive 5000.3, "Test and Evaluation," requires the Assistant to the Secretary of Defense (Atomic Energy), ATSD(AE), to confirm "that Operational Test and Evaluation confirms nuclear survivability and hardness as intended" and ". . . that nuclear survivability and hardness objectives are achieved during development test and evaluation." In addition, DOD Manual 5000.3-M-1, *Test and Evaluation Master Plan (TEMP) Guidelines*, identifies nuclear survivability issues as critical DT&E issues to be "verified by one or more test and analysis techniques."

The DOD Instruction 4245.4 identifies the actions required of each military service and agency developing systems, sub-systems, and programs which have nuclear survivability and hardening requirements. This Instruction also establishes policy and responsibilities for the Office of the Secretary of Defense, the Services, and the DOD agencies.

What Is Required to Satisfy These OSD Requirements?

For those military services and DOD agencies acquiring systems required to be nuclear survivable, DOD Instruction 4245.4 contains the following additional requirements. (Although not specified as PM responsibilities, most of these requirements may fall on you for execution.)

If your system has nuclear survivability and hardening requirements, you are required by DOD Instruction 4245.4 to implement the following nuclear survivability procedures to achieve and verify your system's nuclear survivability and hardness.

—Include nuclear survivability management-level summaries and resource allocation summaries in these documents: *Justification for Major System New Start (JMSNS), System Concept Paper (SCP), Decision Coordinating Paper (DCP), Integrated Program Summary (IPS), and Test and Evaluation Master Plan (TEMP).*

—Develop a cost-effective nuclear hardness maintenance and hardness surveillance program to support the operational phase of the life-cycle nuclear survivability.

—Validate nuclear hardness levels by a cost-effective combination of testing, simulation, and analysis.

—You may be requested to brief the Assistant to the Secretary of Defense (Atomic Energy) concerning the status of your system's nuclear survivability program during the period 90 to 15 working days before the Defense Acquisition Board or DAB (formerly known as the Joint Requirements and Management Board or JRMB, and also as the Defense Systems Acquisition Review Council or DSARC) milestone. Therefore, documentation of nuclear survivability-related decisions is quite valuable to you, and your successor.

—Achieve and verify system nuclear survivability and hardness.

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Dr. Kelley was assigned to the Secretary of Defense Study Team on Defense Agencies and Defense Field Activities from March-September 1987. In October 1987, he returned to the Defense Nuclear Agency to work in the Strategic Defense Initiative Project Office.

—Include plans for testing nuclear survivability and cite adequate resources for this evaluation in the TEMP.

—The provisions of DOD Instruction 4245.4 apply to major (as well as nonmajor) systems which must perform critical functions during a nuclear conflict.

—Notify the Assistant to the Secretary of Defense (Atomic Energy) (ATSD(AE)) if another major or nonmajor system critically limits the survivability of a major system under development. (If the nuclear-survivability of a mission-essential, nonmajor system is degraded by another system, ATSD(AE) should be notified.)

—Re-evaluate the nuclear hardness of systems at selected points during the system's life, particularly after retrofits and after significant changes in the nuclear threat.

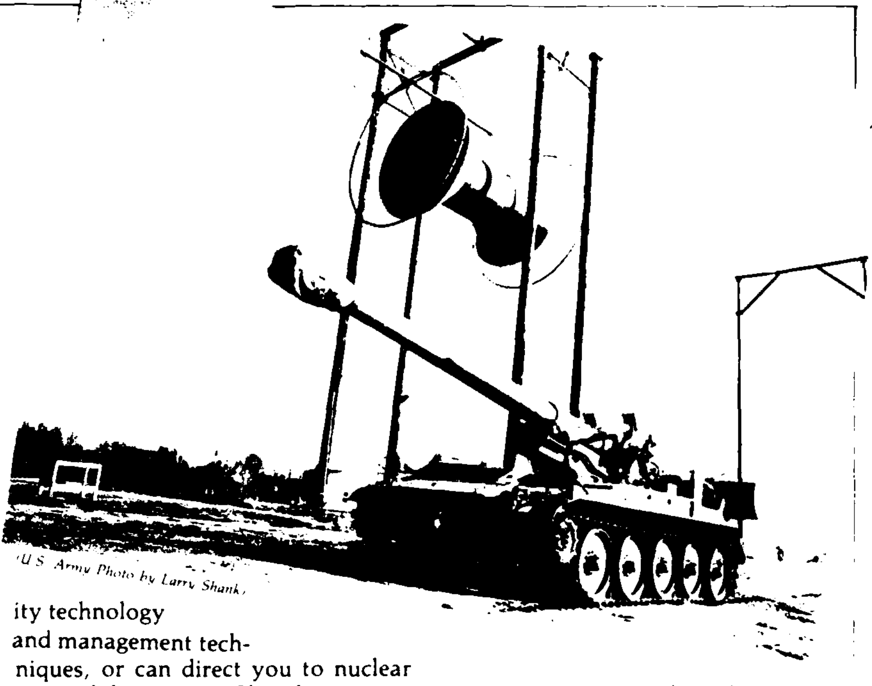
The single, most important thing you must do is to document your decisions pertaining to the nuclear survivability of mission-essential systems, subsystems, and components. This is especially important if your system uses threat avoidance, proliferation, or reconstitution rather than hardening to achieve nuclear survivability.

The Office of the Secretary of Defense is required to monitor nuclear survivability during system acquisition. The DAB process is explicitly required to carefully examine nuclear survivability and system hardness, including the potential impact of each system on larger wartime functions.

—The Under Secretary of Defense (Acquisition), through his cognizant Deputy Under Secretary or the ATSD(AE) may at any time request an informal review of the nuclear survivability of a major system. He may also review the nuclear survivability of supporting systems which must operate jointly in nuclear environments.

—The ATSD(AE) advises the DAB on the adequacy of the nuclear survivability programs of systems in acquisition.

—The Defense Nuclear Agency (DNA) provides technical advice on all aspects of nuclear survivability (less tactics) and hardness. The DNA can assist you in the development of the Nuclear Survivability Program Plan for your system, provide information concerning state-of-the-art nuclear survivability technology and management techniques, or can direct you to nuclear survivability experts. If nuclear survivability testing is required for your system, DNA will help you to identify the appropriate test and simulation facilities and will review your TEMP and other documentation.



(U.S. Army Photo by Larry Shank)

—The DNA provides additional policy, management, and technical information to you and your contractors by publishing *Nuclear Survivability*. (This unclassified quarterly publication is free to DOD and DOD contractors (Critical Technology); send requests to Director, Defense Nuclear Agency, ATTN: NAST, Washington, D.C., 20305-1000, phone (703) 325-7018, (Autovon) 221-7018. The DNA also teaches courses on Nuclear Survivability and Hardness, like the course given periodically at the Defense Systems Management College. These courses can be tailored to your needs and presented to you, your staff, and your contractors upon request. Contact Acquisition Support Division, Headquarters, Defense Nuclear Agency, ATTN: PRAS, Washington, D.C., 20305-1000, phone (703) 325-7018, (Autovon) 221-7018.

—During Developmental Test and Evaluation and during Operational Test and Evaluation, OSD confirms that nuclear survivability and hardness objectives are achieved. Your program documentation, including the TEMP, will be reviewed by OSD before each DAB Milestone in order to ensure that these issues are addressed properly.

—The Head of each DOD component developing a system achieves and verifies system nuclear survivability and hardness.

Each DOD component can use different procedures to attain nuclear survivability (including combinations of proliferation, reconstitution, avoidance of the threat, and hardening). It is your job to implement the most effective option or combination of options.

What Does My Military Service Require from Me?

Each military service has regulations and instructions for implementing policy concerning acquisition of nuclear-survivable systems [11, 12, 13]. In general, military service policies extend nuclear survivability requirements from major systems to include nonmajor systems. They provide guidance on retrofit hardening of some fielded systems, delineate procedures and specific responsibilities, establish control over waivers of nuclear survivability criteria, provide for verification and validation of nuclear survivability and hardening, and provide for establishment of post-production hardness surveillance and hardness maintenance procedures.

Hardening Criteria

During program initiation, your military service decides whether the system is mission critical in a nuclear environment. *If it is, the system must be nuclear survivable.* If hardening is determined to be a necessary requirement, hardening criteria need to be established. For example, nuclear hardening criteria for Army systems are established and monitored by the U.S. Army Nuclear and Chemical Agency. These hardening criteria will be provided to you in terms of physical qualities such as overpressure, peak velocities, energy absorbed, electrical stress, etc.

Normally, you will receive hardening criteria for your system no later than concept selection (Milestone I). You integrate the nuclear hardening criteria into your system via the normal systems engineering process.

How Does OSD Review Systems for Nuclear Survivability?

At the OSD level, the acquisition of major systems is monitored during a sequence of DAB milestone reviews, beginning with Milestone I (which initiates the Demonstration and Validation Phase); and, perhaps, through Milestone III (which begins the Production Phase). A system's nuclear survivability may be reviewed by OSD before any milestone in accordance with DOD Instruction 4245.4. These reviews, normally conducted by the Assistant to the Secretary of Defense (Atomic Energy), usually take place before Milestones I and II.

These OSD reviews examine: (1) the requirement for nuclear survivability, (2) the plan to achieve the required degree of survivability, including documentation and funding, (3) the plan to validate nuclear hardness design, and (4) the plan for achieving hardness assurance, maintenance, and surveillance during the Production and Operational Phase of the system's life cycle. These plans provide the basis for your Nuclear Survivability Program Plan (NSPP). The following Nuclear Survivability Program Questions will help you prepare for an OSD nuclear survivability program review. You can anticipate being asked these questions during your OSD reviews.

Nuclear Survivability Program Questions

1. System Mission: *What is the system mission?*

Is system mission critical/mission essential?

Would the need for the system increase, decrease, or stay the same in the event of a tactical nuclear exchange?

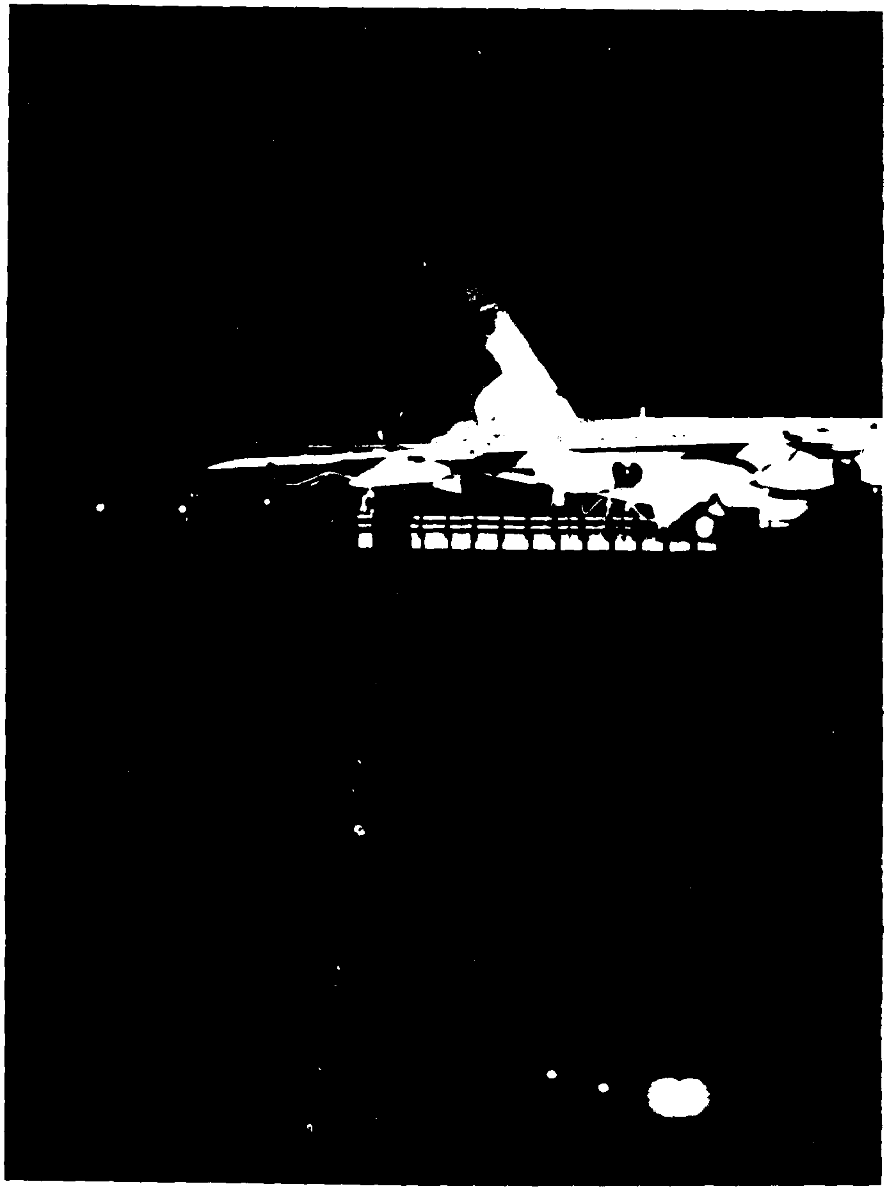
Is the system an essential component of other systems? Are the supported systems mission critical/mission essential?

Are other systems an essential component of this system? Are the other systems as nuclear survivable as this system?

2. Nuclear Survivability Requirements: *Does system have a nuclear survivability requirement?*

If no, why not? Where is the rationale documented?

If yes, how is survivability obtained (proliferation, reconstitution, avoidance of the threat, hardening)? Where is the rationale documented: Is it reflected in sub-system level documentation?



Is there a hardening requirement?

If no, why not? Where is the rationale documented?

If yes, what are the hardness criteria? Who generated and who approved the criteria? Are funds budgeted through the sub-system level? Where is the rationale documented?

3. Electromagnetic Pulse (EMP): *Is the system susceptible?*

Has the PM/SPO/contractor identified supporting systems/equipments which may render the system inoperable after being exposed to an EMP environment; e.g., existing antenna arrays with a new C^3I equipment?

If system is susceptible, is it to be hardened against EMP? Where is this decision documented? If not EMP susceptible, where documented?

What is the role of DOD STD 2169 in system specifications and/or criteria?

4. Program Plan: *Is there a Nuclear Survivability Program Plan?*

What concepts are addressed in the plan?

Where is the program documented?

5. Documentation: *Is the nuclear survivability requirement documented in requirements documents, decision coordinating papers, request for proposals, statements of work, contracts, et al?* List documents and appropriate pages.

6. Validation: *What is the plan for validating nuclear hardening and survivability?*

What is the validation concept (analysis/testing when and where)?

Do facilities, procedures, for validating exist? If not, are they planned and budgeted?

Is this plan documented in the TEMP?

7. Life-cycle Hardness Maintenance: *How will life-cycle hardness maintenance be addressed for hardened systems?*

To what extent will contractors do life-cycle hardness maintenance planning? Is it required in the RFP?

Does a Hardness Assurance Plan (HAP) exist? Where documented? If no HAP, what measures will be taken to assure that design hardness is maintained during production?

Does a Hardness Maintenance Plan (HMP) exist? Where documented? If no HMP, what measures will be taken to assure that routine maintenance, operations, and logistics will not degrade design hardness?

Does a Hardness Surveillance Plan (HSP) exist? Where documented? If no HSP, what measures will be taken to test that routine maintenance, operations, and logistics are not degrading design hardness?

Do facilities exist for hardness surveillance testing? If not, are they planned? How will DOD STD 2169 criteria be related to EMP related hardness surveillance testing?

Is the life-cycle hardness maintenance program budgeted?

How Do I Implement Nuclear Survivability?

Program management activities for developing a nuclear-survivable system are the same as for any other system acquisition activity: acquire an operational capability and acquire life-cycle support for the capability. Once developed and acquired, maintaining your nuclear survivability capability is a must including periodic retest and/or inspection, as required.

You are required to document the nuclear survivability plans for your system within existing Program Management documentation. During nuclear survivability reviews of 31 systems in acquisition, the ATSD(AE) developed the above Nuclear Survivability Program Questions which identify the minimum essential elements which should be addressed in your Nuclear Survivability Program Plan (NSPP). The intent of the NSPP is to outline management approaches and procedures by which you propose to achieve and demonstrate nuclear survivability program tasks, incorporate design requirements when applicable, and conduct demonstrations, tests, or validations. Your Nuclear Survivability Program Plan describes how you will execute your system Nuclear Survivability Program.

What Should My Nuclear Survivability Program Plan Contain?

If you are using hardening to achieve nuclear survivability, the NSPP should describe the design, analyses, tests, and management activities to be performed to satisfy the full-spectrum of nuclear survivability requirements for nuclear weapon effects, which are air blast, thermal radiation, nuclear radiation, electromagnetic pulse, and shock. In the NSPP prepared by your staff or contractor, the functional relationship with other program tasks and milestones should be described clearly. The Plan should identify each task with the work breakdown structure so that you can track and monitor the funds expended and planned for nuclear survivability activities, and so that you can document the nuclear survivability status of your system when called upon to do so.

Your NSPP needs to include the development of nuclear hardness assurance, hardness maintenance, and hardness surveillance programs to assure that system hardening is not degraded through normal usage after production.

Your NSPP should include your system's critical technical and operational thresholds and their relationships to the system's required operational characteristics with respect to nuclear survivability. You must describe the kind and amount of analyses, nuclear weapon effects testing simulation planned, required resources, planned locations, and schedules to achieve nuclear survivability. Your NSPP should:

—Clearly relate the nuclear survivability activity to critical technical and operational issues.

—Show the relationship between planned nuclear survivability milestones and your system's program decision points; i.e., address what will be done relative to nuclear survivability in each program phase.

—Identify points in the acquisition cycle where potential nuclear survivability solutions will be correlated with conventional and chemical-biological warfare survivability to ensure that what enhances survivability in one area does not degrade survivability in another area.

—Identify planned system-level tests or analyses for each nuclear weapon effect for which you have nuclear hardening criteria.

—Provide information concerning your planned use of support data from other DOD components, or the Department of Energy laboratories (for systems having nuclear payloads), and provisions for configuration control with interfacing systems.

—Identify your Preplanned Product Improvement efforts and how nuclear survivability requirements will be validated.

—Include a funding profile that relates your planned expenditures by type appropriation to your planned nuclear survivability activities and milestones.

—Describe your procedure for conveying to subsystem and component designers the latest nuclear survivability design techniques and procedures available at your military service laboratories that are applicable to their particular design areas.

—Describe any resource, such as unique simulators, required to test the nuclear survivability of your system.

Your Nuclear Survivability Program Plan should be no longer than necessary to present the required information. It will be used by you, your military service, and OSD for planning, budget justification, and performance measurement of nuclear survivability. The NSPP provides the basis and authority for all other detailed nuclear survivability documents and should be capable of explaining the intent of your nuclear survivability approach.

Generally, you will not require a new management organization for nuclear survivability; however, a strong PM and contractor management role is essential to guarantee survivability goals are met. You need to manage carefully the nuclear activities in the following areas: system engineering, test and evaluation, manufacturing, and integrated logistic support.

During the system engineering process, treat nuclear hardening criteria as a mission requirement that will be translated into design requirements at successively lower levels of detail. If possible, assign an engineer with nuclear survivability experience to integrate nuclear hardening solutions into your system design. If you do not have nuclear survivability experience within your staff, use the military service labs, the Defense Nuclear Agency or a contractor with a nuclear survivability experience. A continuing series of reviews and audits of technical documentation will help you to maintain control of your nuclear survivability effort.

Your nuclear survivability expert prepares your Nuclear Survivability Program Plan, which details the methods, policies, and guidelines

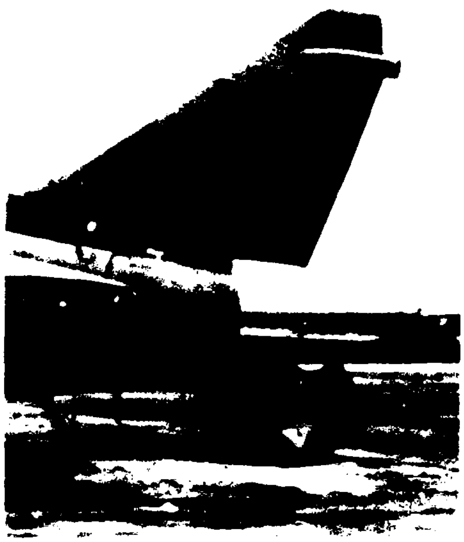
How Do I Manage My Nuclear Survivability Activities?

Without doubt, the first and most important step is to state clearly your nuclear survivability objective in your program documents and contracts. The purpose of this is to ensure that your contractor(s), vendors, inventory manager, operational test and evaluation command, technical manual writers, training commands, reliability engineer, etc., know that nuclear survivability is required.

necessary for incorporating nuclear hardening criteria into the mainstream design plan. Other program plans should include nuclear hardening requirements relative to their specific areas. For example, the maintenance program plan needs to address such hardening specific requirements as hardness-critical items and hardness-critical processes.

Your Contractor's Responsibilities

You should make clear to your contractor that he will be required to perform certain nuclear survivability tasks. He must understand fully your expectations for providing and evaluating system nuclear survivability.



Your contractor must understand that he needs to specify all nuclear survivability critical design parameters for piece-parts, materials, design, and design tolerances. He must plan for sufficient lead time in selecting and scheduling simulation facilities and test equipment, and must correlate overall schedule with such time sensitive facilities as a high-explosive testing or underground nuclear testing.

The contractor will subject your system's equipment to analysis and testing, which it will be expected to pass. Once you are satisfied that your system has been verified as survivable, the contractor must be held responsible for the evaluation of every proposed design and procedural change to determine whether it would jeopardize the hardware's nuclear survivability. Also, he should be explicitly required to develop and furnish nuclear survivability assurance and maintenance.

How Do I Validate My Design?

You will not be able to expose your system to the full nuclear weapon effects environment because of the ban on above-ground testing. Accordingly, simulation and analyses are essential activities for the test and evaluation of nuclear survivability and hardness. No nuclear weapon effects (NWE) simulator duplicates every NWE environment. Most facilities, in fact, simulate only one nuclear weapon effect, so your equipment may need to be exposed to effects from several simulators in order to verify system nuclear hardening requirements. Additionally, analyses are needed to fill the voids where simulation is not available (i.e., some of the synergistic impacts of different environments), and to extrapolate from simulated testing levels to projected threat levels.

You need to develop a comprehensive, nuclear hardening developmental test and evaluation (DT&E) program that includes both simulation and analysis. Your DT&E methodology must validate with high confidence that your design meets the nuclear survivability criteria. Your TEMP will be used by OSD in the review and decision process to assess the adequacy of your planned testing and evaluation, including nuclear survivability and hardening test and evaluation. In order to satisfy the objective of verifying that system nuclear survivability and hardness requirements are met, you must ensure that your system test plans describe in detail the total verification program from piece-part to system-level testing and analysis.

The approach you take to validate nuclear survivability is very much dependent upon your system's architecture. For example, if your system is a large and widespread system that has many penetrations, you will require a more complex and very different electromagnetic pulse validation effort than that for a system which has only a few, controlled penetrations. A complex system requires thorough analyses, on and off site tests of protection components, shielding effectiveness tests, and possibly a degree of extrapolation to reduce the degree of uncertainty in the test results. For a less complex system, on the other hand, the analysis and testing are simplified. In general, as the size and complexity of the system increase so do the size and complexity of the test and evaluation program of that system.

As part of your production engineering analysis, your production engineers define the impact of system design on production resources and they develop manufacturing alternatives. Results of this analysis need to be documented in your Production Plan. Nuclear hardness assurance activities are described in the product assurance section of your production plan, as well as being summarized in the ILSP.

Hardness assurance is different than design hardness. When hardness is built into design, there must be assurance that the production line activities build your system to design hardness. The following definitions of hardness assurance at the system and piece-part levels will help you to maintain a hardness assurance program consistent with your quality assurance program.

System Hardness Assurance. The procedures applied during the production phase to ensure the production process and end-product are in accord with the hardened design and in compliance with the nuclear hardening specifications.

Piece-part Hardness Assurance. The procedures, controls, and tests used to ensure that a purchased piece-part has a response to nuclear-induced stresses within known and acceptable limits.

The planning of hardness assurance should begin early on, with in-depth reviews of the preliminary design drawings before prototype fabrication. Mission critical parts that are sensitive to one or more nuclear environments must be identified on the drawings and parts list for testing, inspections, and controls per MIL STD 100C. These are referred to as Hardness Critical Items (HCI). The survivability you have designed in and have verified must be maintained . . any final design changes must be evaluated to ensure

that there is no degradation in nuclear survivability. All processes, specifications, and procedures which are hardness critical and which, if changed, could degrade nuclear hardness are Hardness Critical Processes (HCP). The HCPs must be identified in the drawings and drawing notes, as well as in the technical manuals.

Your final technical and production data packages must thoroughly account for hardness assurance, including nuclear survivability design parameters, production assurance procedures, and the required manufacturing process. As final configuration nears, the importance of audits increases. The nuclear survivability design parameters must be reviewed in both the functional configuration audit and the physical configuration audit.

How Do I Integrate Logistic Support?

Your planning for logistics begins in the Concept Exploration Phase of the acquisition process with the development of supportability assessment plans and criteria. These criteria should include nuclear survivability requirements. These requirements are placed in the system specifications to ensure they are considered in the design of the system and to serve as a basis for the Logistic Support Analysis (LSA) Plan. The LSA Plan is developed during the Demonstration and Validation Phase and implemented in the Full-Scale Engineering Development Phase.

The basis for all Integrated Logistic Support (ILS) activities is described in your Integrated Logistic Support Plan. This plan defines organizational relationships and tasks, how the Logistic Support Analysis will be conducted, the life-cycle support concept, and all the aspects of logistical support. Your nuclear survivability expert needs to work closely with the logisticians to assure that survivability-related logistic requirements are included in the Integrated Logistic Support Plan.

Your nuclear survivability expert supports your logistics planning and execution effort by incorporating detailed qualitative and quantitative hardening requirements into the Logistics Support Analysis; together, they determine the required hardness maintenance tasks and the required hardness surveillance tasks. Through this process, special tools, test equipment, and unique facilities are identified. Nuclear survivability and hardness are built into your system during the Production Phase. Nuclear survivability does not end there, however: Proper Integrated Logistic Support ensures that hardness is maintained throughout the life of your system.

What Is This Going to Cost Me?

Experience has shown that Nuclear Hardening costs are typically 1-5 percent of the total development cost, with 10 percent being a rough maximum. Production cost increases are typically 1-3 percent. You can lessen your cost by starting your nuclear survivability effort as early as possible. A later redesign or retrofit to achieve nuclear survivability can only increase the cost of your system. Navy analysis indicates that retrofit hardening (not including maintenance and logistic support cost) will increase production cost approximately 17 percent.

Analysis and testing almost always account for a lion's share of the cost. These costs generally are independent of criteria levels. In other words, nuclear survivability costs "something," regardless of the survivability level. Your staff efforts and documentation will not be affected much by criteria levels either. For one system, a criterion quadrupled, but the cost remained about the same. The same analyses and tests were required, but production modifications were negligible.

One thing is clear. When the hardening decision is made and pursued *early* in the acquisition process, the process is cheaper and more effective. Start early and stay with it! Doing so saves a lot of time and effort later, which further increases your dollar savings. In particular, delaying unnecessarily beyond prototype development further increases hardening cost.

Lessons Learned

The primary lesson learned during OSD reviews is to start nuclear survivability planning as early as possible; i.e., plan for nuclear survivability "up front and early on." An early start will reduce the cost and risk associated with retrofitting nuclear survivability. Other useful lessons are described below.

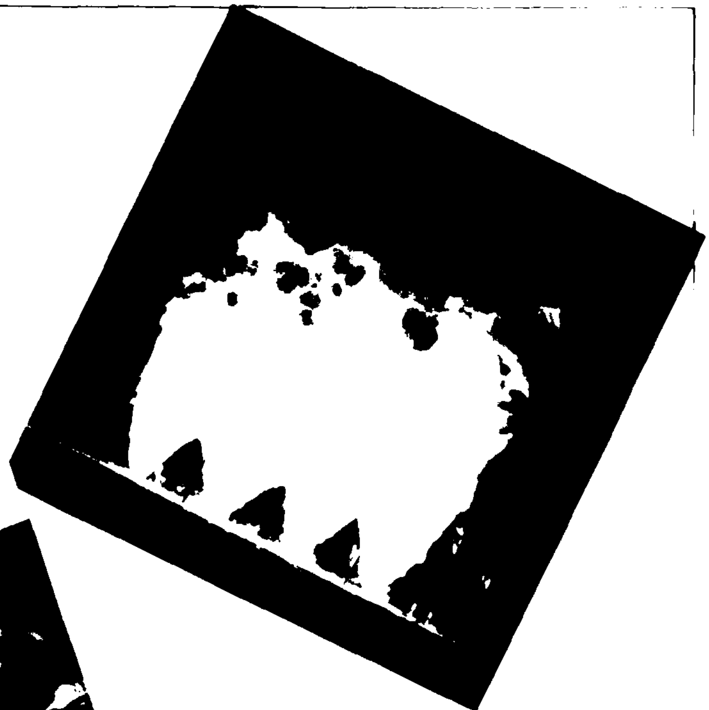
Experience. Government laboratories, weapon effects personnel, and the Defense Nuclear Agency can provide technical and programmatic support for your nuclear survivability effort. Involve military service and DOD Developmental Test and Evaluation and Operational Test and Evaluation organizations early to identify the testing and evaluation necessary to validate your nuclear survivability design. Your primary contractors may want to subcontract to organizations with nuclear survivability experience.

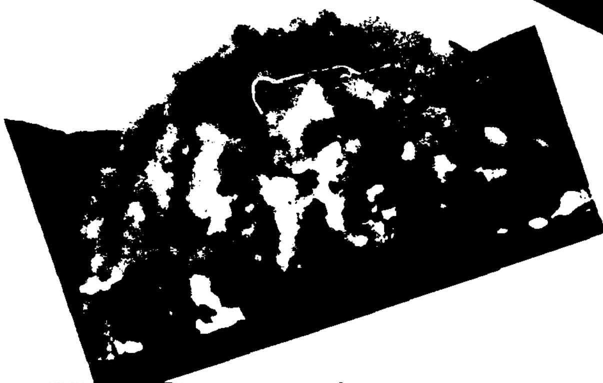
Contracts. Before contracting, get experienced nuclear survivability advisors involved to review your procurement package so that you can be clear to your contractors concerning nuclear survivability efforts, including system-performance requirements and the use of simulators to verify some nuclear-weapon effects. Make sure your contractor is provided with all pertinent documentation.

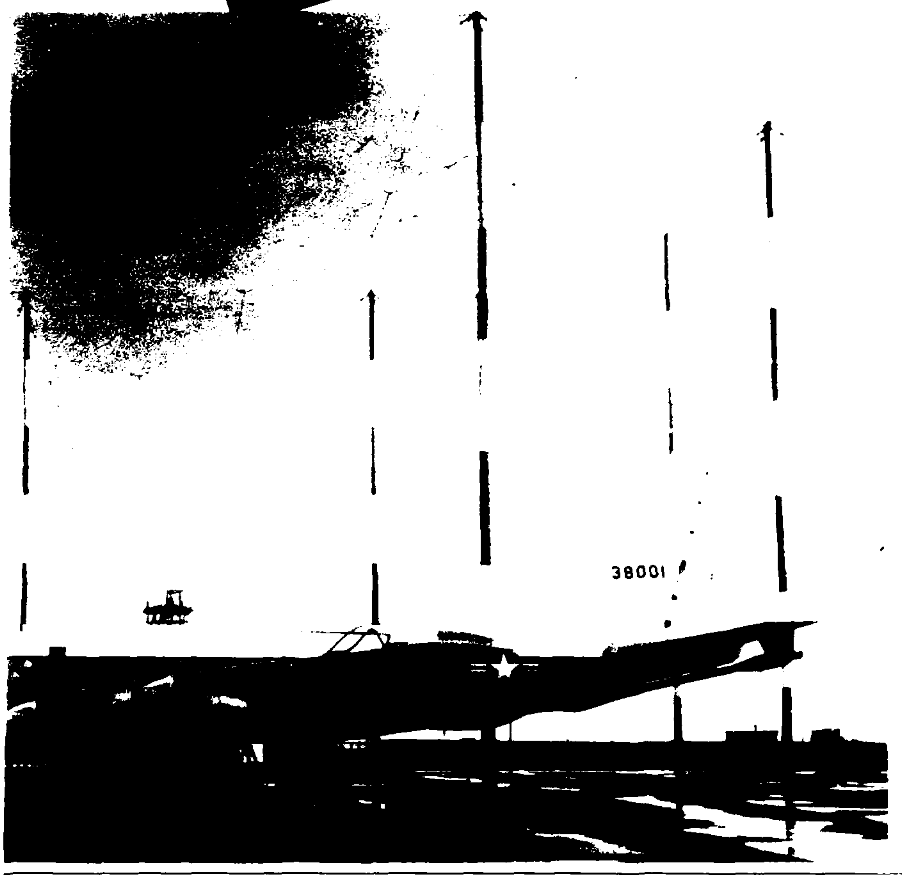
Delays in Implementation. You must make your expectations known early, enforce milestones and evaluate contractor task performance. This will ensure that long lead-time nuclear

hardened items are available for final prototypes, that space and resources are available for nuclear survivability items, and that your acquisition schedule is not delayed while you retrofit design changes to incorporate nuclear survivability.

Task Appraisals. This area is related to delays in implementation. You and







your staff must be on top of contractor tasks and progress in order to keep the effort on track and on time. Use your staff nuclear survivability expert or seek assistance from the appropriate supporting government organization.

Documentation. You must ensure that your contractor is provided with any needed documentation. In some cases, requirements exist yet documentation is weak, analytical tools are lacking, there is insufficient data, or needed test facilities are inadequate, non-existent or unknown to you and your contractor. Where you see confusion, you must ensure the development, coordination, documentation and dissemination of preferred procedures. The contractor's documentation is equally important. Ensure he is providing specific, detailed information from preliminary design through all nuclear survivability related activities for OSD review. The flow of documentation must not be delayed or it causes problems. Classified documents are particularly vulnerable because of the extra processing time and additional players involved.

System Survivability. All mission essential parts of a nuclear-survivable

system must be nuclear survivable. Some government furnished equipment (GFE) is not. You must ensure that the nuclear survivability of your system is not degraded by any GFE which is not survivable. If the equipment is developmental, you must work with and convey your requirements to the developer. If you are using off-the-shelf GFE, you need to ensure that, if necessary, the items are product-improved to meet your system Nuclear Survivability Criteria. With success-oriented schedules, a contractor may not be able to diagnose simulator-induced equipment failure on site. Your statement of work should require the contractor to state his required actions and to submit detailed reports of his failure analysis and redesign recommendations.

Maintaining Nuclear Hardness. Develop a viable nuclear hardness surveillance and maintenance program to protect your nuclear survivability investment established during the development of your system. Experience has shown that weapon system nuclear hardening can be degraded significantly during normal operation if not monitored and maintained. Without a formal hardening maintenance program, improper maintenance procedures may be applied or unhardened parts used when nuclear hardened parts are required. Develop a well-coordinated nuclear surveillance and maintenance program and incorporate it into your Integrated Logistics Support Plan.

Survivability problems can be avoided or their impact reduced if your Nuclear Survivability Program Plan is properly prepared and if you ensure that your NSPP is followed throughout the acquisition of your system. Review these lessons learned when preparing your Nuclear Survivability Program Plan.

Assistance with nuclear survivability policy, technical, and programmatic matters is available from all of the military service staffs and laboratories, the Defense Nuclear Agency, and DOD and Service data bases and information centers.

Summary

The acquisition of enduring, nuclear-survivable, mission-critical systems is required to enhance the continued deterrence of nuclear war. Nuclear survivability is achievable. When addressed early in the design process, nuclear survivability costs are reasonable.

To produce a nuclear-survivable system, develop a Nuclear Survivability Program Plan, incorporate nuclear survivability early, thoroughly document your rationale and decisions, stay informed, and use nuclear weapons effects experts. Develop plans to ensure that nuclear survivability is acquired and maintained throughout the life of the system.

Educate your staff. Use state-of-the-art nuclear survivability technology and management assistance available from DOD agencies, the military services, and your contractors. ■

End Notes

1. The DOD Instruction 4245.4, "Acquisition of Nuclear-Survivable Systems."
2. Ibid.
3. Ibid.
4. The DOD Directive 5000.1, "Major System Acquisition."
5. The DOD Instruction 5000.2, "Major System Acquisition Procedures."
6. The DOD Directive 5000.3, "Test and Evaluation."
7. The DOD 5000.3-M-1, *Test and Evaluation Master Plan (TEMP) Guidelines*.
8. The U.S. Army Regulation 70-80, "Nuclear Survivability of Army Material."
9. The OPNAV Instruction 3401.3, "Nuclear Survivability of Navy and Marine Corps Systems."
10. Air Force Regulation 80-38, "Management of the Air Force Survivability Program."
11. U.S. Army Reg. 70-80.
12. OPNAV Inst. 3401.3.
13. AF Reg. 80-38.

Whenever in this publication "man," "men," or their related pronouns appear, either as words or parts of words (other than with obvious reference to named male individuals), they have been used for literary purposes and are meant in their generic sense. ■

Army Develops Materiel For Tactical Deception

Tactical deception stimulating deployment of tanks, trucks, helicopters, missile systems, communications and logistics support equipment on the modern battlefield have been developed. The Army Troop Support Command Belvoir RD&E Center, in conjunction with the Communications-Electronics, Missile and Laboratory Sub-Commands of the Army Materiel Command, is expediting an integrated deception program addressing the complete spectrum of threat sensors.

During the past year, the Center conducted four concept evaluation programs to develop and demonstrate devices to simulate combat equipment and high-value assets on the modern battlefield. Systems ranging from simple billboard-type tank decoys to complex communications systems were designed, fabricated and delivered to troop units for field evaluation in 1 year. Evaluations were successful and the Army directed immediate limited acquisition and fielding and early production of the four systems.

PRT Elects New Directors

Elmer B. Staats, Chairman of the Procurement Round Table (PRT) and former Comptroller General of the United States, has announced the election of three new directors.

The new directors are: Ray Kline, President, National Academy of Public Administration; Charles W. Stewart, retired President, Machinery and Allied Products Institute; and RADM William M. Zobel, USN (Retired), former Commander, Naval Facilities Engineering Command.

MANAGEMENT

GOVERNMENT PROCUREMENT REFORMS

The Need to Consider Long-Term Effects

There is an urgent need to assess the long-term impacts of changes in procurement laws and policies that have been made in, or proposed by, the federal government on our nation's capability to acquire essential goods and services effectively and efficiently in the year 2000 and beyond. As a nation, we must ensure that long-term national interests are not adversely affected when actions are taken to correct actual or perceived near-term problems.

This report identifies and discusses the underlying causes of changes made in, or proposed for, government procurement which have possible long-term adverse effects, and makes recommendations for evaluating changes in laws or policy impacting the procurement process. It is our deep concern that steps taken because of understandable, short-term problems will have serious effects on the viability of the defense industry and its ability to support our security interests during the next decade or two.

Procurement Process

This nation's procurement process is large, complex, and difficult to manage. It expends large sums of public funds affecting the security of the nation and its industrial and economic condition; and there have been many problems and deficiencies associated with the process. Some are long-standing concerns—inadequate competition, program instability, and the use of proper types of contracts. Others, new in emphasis if not in title, often are referred to as "waste, fraud, and abuse," and represent issues receiving much attention currently or in the recent past. They include matters like truth in negotiations, rights in technical data, profit policy, spare parts, pricing, contractor investments, cost allowability, independent research and development, revolving door, work measurement, suspension and debarment, progress payments, cash management, using fixed-price type contracts, application of competition concepts, self-governance, voluntary disclosure, commercial pricing and overhead certification, travel regulations, industrial base, material requirements planning, and contractor facilitization.

For the most part, these are not frivolous concerns on the parts of individuals and organizations wanting an improved, or reformed, government procurement process. The four underlying concerns for recent and proposed changes in the laws and policies appear to be:

—Doubts about honesty and integrity on the parts of buyer and seller

—Costs of purchased items

—Degree or level of profitability for the seller

—Insufficient risk assumption and investment by industry firms.

Contractor Honesty

Defense industry firms have been criticized for unethical and corrupt conduct, and the integrity of government contracting personnel has been questioned. The President's Blue Ribbon Commission on Defense Management (Packard Commission), recognizing the seriousness of this problem, especially as it relates to public confidence in national defense and the defense industry, called for a higher level of ethics and trust in government contracting. The Commission stated: "Defense contractors and DOD must each assume responsibility for improved self-governance to assure the integrity of the contracting process. Excellence in defense management will not be achieved through legions of government auditors, inspectors and investigators...it depends on the honest partnership of thousands of responsible contractors and DOD, each equally committed to proper control of its own operations.[1]

As a result of the Packard Commission emphasis on integrity, 37 industry firms, representing more than half of the total DOD procurement spending, have adopted as guidelines and principles a set of "Defense Industry Initiatives on Business Ethics and Conduct." There is a belief in the minds of some officials—government and industry—that implementing these initiatives will need testing and assessment to achieve intended objectives. Complicating this problem, however, are some troubling aspects of the initiatives and other disassociated efforts to make the system more honest. Examples are:

—While in accordance with the Packard Report, the guidelines on voluntary disclosure may not provide appropriate immunities or limitations on access to documents. This is a matter of high importance since such disclosures could result in criminal prosecutions of either contractors or their employees, civil false claim suits, and possible automatic suspension of contractors at the time of disclosure. Also to be considered are contractor employee rights.

This is a report of the Procurement Round Table (PRT), a non-profit corporation whose purpose is to inform the public and the Congress about the federal procurement process, to study and report on procurement issues, and to make recommendations for improvement to the federal procurement system.

This report was initially prepared by Robert F. Trimble, a member of the PRT board.

—While long available in some agencies, telephone hotlines are being stressed as a way to permit contractor employees to report directly to the government on internal contractor matters. This can trigger investigations and public attention before contractor management is aware there is, or may be, a problem. The challenge is how to use this communication technique effectively while avoiding frivolous, mischievous allegations being pursued with disruption to government and industry.

Qui Tam, a legal concept for paying individuals who bring to justice those who are defrauding the government, was strengthened in an amendment to the Civil False Claims Act. It brought attention to this legal procedure and provided additional incentives for individuals to allege wrongdoing and damage a contractor's public image.

The new Program Fraud Civil Remedies Act provides for subpoena power, investigation, prosecution, and conduct of trials outside the federal judiciary. This added authority subjects contractors to more litigation, adverse publicity, and intimidations in handling contract issues and settling claims.

Efforts to maintain honesty and integrity in the government procurement process are well intended, but it is not clear whether their potential long-term effects on industry-government relationships were considered. As the Packard Commission found, honesty is not a major problem in government procurement. Too much technical criminalization of the process for administering government contracts can have serious, long-term, adverse effects on the teamwork needed between government and industry essential for the efficient and effective fulfillment of the government requirements. Thus, positive efforts must be taken by the government to avoid actions that constitute an overkill.

Reductions in Government Costs

Our government procurement is the largest business enterprise in the world. "Annual purchases by DOD total almost $170 billion—more than the combined purchases of General Motors, Exxon, and IBM. The DOD research and development expenditures are more than fifteen times those

Annual purchases by DOD total almost $170 billion more than the combined purchases of General Motors, Exxon and IBM.

of France, Germany, or the United Kingdom, and eighty times those of Japan. Defense acquisition involves almost 15 million separate contract actions per year—or an average of 56,000 contract actions every working day."[2] Changes or system improvements that increase the economy or efficiency of the government procurement process offer the potential for sizable dollar savings.

Many efforts have been made to improve the procurement process as a whole and to ensure that individual programs are handled well. Contracts personnel in the government and individual contractor firms have worked hard to correct deficiencies and lower costs. In addition, the Congress, the White House, and DOD have individually and collectively sponsored many studies and analyses—sometimes under prestigious commissions—to determine how the process can be operated more effectively and efficiently.

The Packard Commission recommendations to improve competition, use technology to reduce costs, expand the use of commercial products, and enhance the quality of acquisition personnel are representative of actions that can result in significant cost savings. However, additional changes have been made by the Congress and DOD. These appear to have been made on a case-by-case basis, without in-depth evaluation of their long-term effects. Some examples are:

—Requiring fixed-price type contracts for high-risk phases of the weapons acquisition process that in the past used cost-reimbursement type contracts

—Requiring premature commitment by contractors to definitive prices for production

—Requiring contractors to invest in special tooling and special test equipment

—Reducing the rate or level of contract financing through DOD progress payments

—Improperly applying performance warranties for immature systems and insistence on no-cost warranties

—Reducing or futher restricting DOD support of contractors' independent research and development and bid and proposal costs

—Increasing the scope of government audits, resulting in duplication of efforts among audit and review activities

—Preempting rights in contractor technical data

—Mandating refunds for spare parts.

The intent of these initiatives has been partially to reduce both the initial acquisition cost and total program cost of weapon systems during a period of military buildup and equipment modernization and consequent DOD budget stress. For example, fixed-price contracts can transfer risks of expensive technical problems arising during development and initial production to the contractor, thus protecting the government. Increased contractor investment can make some suppliers more comparable with commercial marketplace suppliers and reduce government outlays during preproduction phases. Reducing government expenditures for research and development presumably will result in contractors absorbing these costs in an effort to remain in contention for new pro-

duction programs. Alternatively, such reductions may change the nature of independent research and development efforts forcing contractors to reduce basic research in favor of research and development which addresses near-term competitive situations.

Initiatives with short-term budget relief are appealing but the negative long-term effect can more than offset any short-term gain. For example, coordinated single-service policies caused by disruptions in the procurement system can result in longer procurement lead times and cost to the government. The need for a reliable, available industrial base for peacetime and wartime, and a sensitivity to industry's need to attract both investment and operating capital is ignored.

Levels of Profitability for Contractors

Concerns about the level of profits government contractors earn are as old as the nation. The Congress and the Executive Branch have responded to charges of unreasonable contractor profits with a succession of laws, regulations, investigations and studies. Much time and effort is spent to decrease the level of defense contract profit.

In its most elementary form, profit is the excess of price over cost and represents a compensation to the seller for assuming risks and investing in personnel, plant and equipment, and other financial and technical resources. Buyer and seller in government contracting share the responsibility for a fair and reasonable profit level essential to achieve public trust and compensate for investment and risk in a free market.

Recently, however, there seems to be a tendency to confuse "going in" profit markup in a contract price with actual realized profit. Profit markup is the difference between estimated costs and negotiated price; actual realized profit is the difference between actual cost and price. There may be little relevancy between the two in any given contract. For instance, significant growth in costs in a fixed-price type contract can result in loss rather than profit regardless of assumed fee; or profits may exceed initial targets as a result of good management, good luck or other factors. The usual case is a profit degradation from markup.

Assessing correct levels of profit under differing types of contracts involving different situations has been the subject of several recent studies and analyses. The Defense Financial and Investment Review (DFAIR) has been the most prominent. Conducted by DOD during 1984-85, DFAIR constitutes a comprehensive "...study of contract pricing, financing, and profit (markup) policies to determine if they are resulting in effective and efficient spending of public funds and maintaining the viability of the defense industrial base...."[3] This effort was followed by a separate study conducted by a Department of the Navy contractor and a comprehensive critique of DFAIR by the U.S. General Accounting Office.

The DFAIR report concludes that "Current contract pricing, financing, and markup policies are balanced economically, are protecting the interests of the taxpayer, and are enabling U.S. industry to achieve an equitable return for its involvement in defense business."[4] Both the Navy study and the GAO report criticize DFAIR on the basis that there are flaws in the analytical logic used in its study.

Reactions to the various analyses of DFAIR and high-level interest in profits resulted in a number of important government policy changes:

—A new DOD profit policy, effective October 18, 1986, adjusted the weighted guideline method for determining profit objectives intended to reduce by one percentage point overall levels of profit. This is, in effect, a ten percent reduction in profits.

—Profit is not allowed on costs of IR&D and general administrative expenses.

—More costs are classified as "unallowable" elements for contract payments. For example, foreign selling costs are not recoverable; limits have been placed on the reimbursement of travel costs; and the push for more competition has increased dramatically costs for independent research and development and bid and proposal costs without commensurate increases in maximum reimbursements for such costs.

—Profit is reduced on undefinitized contract actions.

—Warranties for performance requirements and for labor and material are sought on a "no-cost" basis.

—Contract financing is reduced by lower progress payments, thus increasing contractors' interest payments which are the major elements of unallowable costs.

Thus, on the one hand, profit objectives are reduced; on the other hand, unallowable costs and risks are increased. What is not known and perhaps not adequately researched is whether new profit policies will result in profit levels required to ensure, in a free-market economy, that firms with appropriate capabilities will be motivated to invest in new technology, facilities, and equipment; that stockholders will be satisfied the defense market is a suitable place for investment capital; and whether, in the long term, the nation will have a robust industrial base adequate to satisfy its national defense needs.

Transfer of Risks

It is risky for contractors to conceive a weapon system involving new advanced technology, to develop and test the design, and to place it into production. Weapon development probably constitutes the riskiest of all situations in government contracting because of many unknown factors. There also are elements of high risk in many other federal programs of a non-developmental nature involving large amounts of public money; e.g., space vehicles, waste disposal facilities, or new transportation systems.

Risk sharing has been used to ensure that the government does not place too much risk on private sector firms. Contract types from cost plus fixed-fee to firm-fixed price have been used, with appropriate terms and conditions, to ensure fairness and equity between the government and the contractor.

However, a recent shift in thinking on risk allocation appears to have taken place within the government. Some initiatives call for more fixed price contracting, less use of economic price adjustment provisions, restricted use of contractor indemnification, addition of performance warranties, and greater investment in special tooling and special test equipment. These factors, coupled with intense competition, can cause reputable contractors to abstain from government contracts, and

others to undue risks in lieu of experiencing serious short-term business losses. The effect is to make government contracting a high-stakes game—sometimes for a company and also for the government.

Since World War II, the United States has relied on the private sector free enterprise system for most public requirements for goods and services. The government market is not the relatively free marketplace of commercial buying and selling, however, and is subject to many more constraints, rules, and procedures. The government does, through one technique or another—setting profit levels and varying contract financing and risk assumption—actually regulate the defense industry. At the same time, free-market economy forces are at work involving capital formation and willingness to play in the defense market. Changing rules can have long-term effects on relationships involving a semi-regulated business operating in a free market.

Although some members of the Congress and some DOD officials concluded that defense industry profits are too high and risk is too low, and are taking steps to lower profits and increase risk, the capital formation market appears to be telling a different story. According to a recent Paine Webber analysis, the stock market is discounting large defense company stocks in excess of 50 percent compared to the Standard & Poor 400. This analysis observes that while government efforts to improve defense acquisition are commendable, policies enacted in a piecemeal fashion, without careful consideration of macro industry, economic and political factors, could have far-reaching and unintended negative consequences for the structure of the defense industry. Another analyst observed that "...the specter of further tinkering with profit margin regulations is keeping investors out of the defense market."[5]

Conclusions and Recommendations

It is not known whether the effects of government action will result in profits that are too low, as investors appear to believe; nor is it known what effects these changes in profit levels will have on company behavior and the structure of the industry. Government and industry, however, should understand these factors better before continuing changes to the procurement process.

The PRT, like the DOD and the Congress, is concerned about any perceived or actual efforts to defraud the government. It is especially interested in assuring that all reasonable efforts are taken to increase the economy and efficiency of the acquisition process. It is also concerned with the need for a viable industrial base to meet the nation's needs in the year 2000 and beyond. Balancing short-term objectives with these long-term requirements will require a high order of management competence and the best efforts of government and industry.

The PRT makes the following recommendations with respect to these concerns:

—**DOD Action.** Establish an Industry Advisory Board (IAB), supported by a full-time expert staff, to provide a regular, systematic basis for communicating on key problems and issues affecting the entire DOD-industry relationship and the health of the industrial base.

First, the IAB staff would study long-term effects of current statutes and regulations described in this paper, and report the findings to the Secretary of Defense and the Congress.

The IAB should be of the stature and quality of the former Defense Industry Advisory Council (DIAC) of the 1960-1970 time period and of the Defense Science Board today. A project to establish such a mechanism is taking place in the Office of the Assistant Secretary for Production and Logistics.

—**Government-Wide Action.** The Office of Federal Procurement Policy (OFPP), whose reauthorization is now before the Congress, should have government-wide responsibility in its reauthorization charter to coordinate the Executive Branch position on all procurement legislation—current and proposed—to assure the testing and assessment of long-term impacts and to seek the best ground rules to govern both industry and government in all aspects of federal procurement.

To assist in this role, a Procurement Advisory Board of elder statesmen and current experts should be formed to give continuing proposals and advice to OFPP. One of the continuing interests of this mission would be to merge the Federal Statutes governing procurement into one coordinated body of laws, and the continuing oversight of the Federal Acquisition Regulation program to maintain government-wide consistency and simplicity. ■

Cited Footnotes

1. *Final Report to the President* (June 1986), p. xiii.
2. Ibid, p. 43.
3. *Defense Financial and Investment Review* (June 1985), p. E-1.
4. Ibid, p. E-1.
5. "Defense Stocks Are Left in the Dust of Wall Street's Raging Bull Market," *Defense News*, February 2, 1987.

Engineers from the Fuels Handling R&D Team, Belvoir Research, Development and Engineering Center are preparing the technical data package for the Artic Fuel Dispensing Equipment (AFDE) that will operate in temperatures as low as minus 60 degrees Fahrenheit. There is no Army system that can store and dispense military petroleum fuels at temperatures below minus 25 degrees Fahrenheit.

The ADFE includes the Arctic Forward Area Refueling Equipment, which will be deployed by helicopter, and the Arctic Fuel System Supply Point, which will perform a bulk fuel storage and supply mission.

The AFDE has been successfully tested in Alaska. The program schedule shows type classification by the end of fiscal 87 with fielding in late fiscal 90. ■

"Duty is the sublimest word in our language. Do your duty in all things. You cannot do more. You should never wish to do less."

—General Robert E. Lee.

The People's Republic of China

An Awakening Giant

David D. Acker

The goal of my three-part report is to explore the culture and viewpoints of the Chinese people, ideas and concepts pervading their society, reasons they act in certain ways, and events leading to the organization of their society today. Through a clear understanding of Chinese culture and viewpoints, we can recognize their people as similar to us, yet who act and think in distinctive ways. One scholar has said that, *"Understanding a people's culture exposes their normalness without reducing their particularity....It renders them accessible."* [1] We can improve our vision and understanding of the Chinese by carefully observing what they have said and done.

Since the United States and the People's Republic of China, referred to hereafter as China, normalized relations in 1979, both countries have displayed a willingness to develop a military relationship. This willingness is predicated on our assessment that we share important parallel interests from global and regional viewpoints, the most important being the common security threat posed to both countries by the Soviet Union. In a recent article in *Defense/87*, Assistant Secretary of Defense for International Security Affairs Richard L. Armitage, said *"an objective of our (Department of Defense) policy is to build an enduring military relationship with China that will support its national development and maintain China as a force for peace and stability. A more secure, modernizing, friendly China—with foreign policy and economic system increasingly more compatible with the West—can be a constructive factor in world affairs and make a significant contribution to peace and stability.... Accordingly, we have focused our efforts on achieving balance in three key elements of the relationship: high-level visits and dialogue, military-to-military exchanges, and military-technology cooperation. During the past year, we witnessed notable developments in each element, highlighted by the extremely successful return visit to China by Secretary of Defense Caspar W. Weinberger and followed in quick succession by the historic U.S. Navy ship visit to the port of Qingdao and signing of the F-8 avionics foreign military sales program letter of agreement. The development of U.S.-China military relations has been, and continues to be, a fundamental element of our China policy."* [2]

With this background, the Defense Systems Management College thought it desirable to learn more about Chinese values, patterns of behavior, beliefs, and ways of thinking. I, therefore, went to China and this is a report of my findings.

The challenge of this report was exciting not only because more than 20 percent of the world is Chinese, but because Americans belong to a complex civilization; seeing how another civilization evolved can teach us much more about ours.

Introduction

The People's Republic of China was established Oct. 1, 1949, under the leadership of Mao Zedong (Mao Tse-Tung). Twenty-eight years later, Jan. 1, 1979, normalization—establishment of formal diplomatic relations between the United States and China—was achieved. Normalization had been the formal goal between the two governments since President Richard M. Nixon's first visit to China in February 1972, but it took 7 years to fully achieve.

Since normalization, an important aspect of Sino-American relations has been the way bilateral agreement is implemented. First, normalization has been extended from the diplomatic sphere to the economic sphere. Second, a complex network of relationships has been established connecting governments and societies of both countries. Third, military and security relationships developed more quickly than many thought possible. Our relations with China have progressed far beyond normalization in the broadest definition of the term.

China, historically and culturally, is one of the world's richest countries. Today, its citizens and visitors can enjoy restored ancient buildings and works of art. This especially interests Americans wanting to experience a different culture, to observe historic buildings in natural settings, and to examine time-honored handicrafts.

The American Society of Mechanical Engineers

■ *Mr. Acker is a Professor of Management at the Defense Systems Management College. He accompanied a group of engineering managers to China in April.*

China has the potential to be a major force in the world economic community. Because of vast natural resources and a high level of scientific and technological awareness and accomplishment, China could become closely involved with industrialized nations of the West. The Chinese appear to have a strong desire to develop engineering capabilities on a broad scale to achieve modernization goals. They have a high level of self-reliance.

Background of Visit

The invitation for engineering managers to visit the People's Republic of China came from The Chinese Mechanical Engineering Society (CMES) to The American Society of Mechanical Engineers (ASME) General Engineering Technical Group, through the Director of Science and Technology Projects for the Citizen Ambassador Program of People to People International. The ASME invited me to join the American professionals in engineering management. Our basic purpose in April 1987 was to exchange ideas and experiences with Chinese professional engineers and managers concerning the role of engineers in management and the management of engineers. My participation was endorsed by the Defense Systems Management College.

The Chinese Mechanical Engineering Society

The Chinese Mechanical Engineering Society with its 20 technical institutes, including the Management Institute, plays a major role in the modernization of Chinese engineering efforts. Through 327 branch offices, CMES serves 130,000 members by providing academic activities, technical research, and standards development. The CMES, working in conjunction with the Citizen Ambassador Program, arranged our agenda.

People to People International

People to People International was founded in 1956 by President Dwight D. Eisenhower, who assigned its operation to the U.S. State Department to further international understanding. Eisenhower's perspectives gained as Supreme Allied Commander and, later, as President led to his belief that private citizens reaching out in friendship to people of other nations could make a significant contribution to world peace. In his Report to the Nation after the Geneva summit talks, President Eisenhower called for "increased visits by citizens of one country to another to give each the fullest opportunity to learn about the people of other nations...." As a result, People to People International became a reality in June 1956, and in 1961, it became a private non-profit organization. Presidents John F. Kennedy, Lyndon B. Johnson, Richard M. Nixon, Gerald R. Ford, and Ronald W. Reagan have been honorary chairmen.

Today, People to People International promotes friendly relations among countries through scientific, professional, and technical exchange. Because no country has a monopoly on talent, communication among specialists working at the forefront of their disciplines is essential to professional and scientific advance. Face-to-face

The Chinese Mechanical Engineering Society

communication allows colleagues from different countries to discuss problems, compare recent findings, and evaluate areas for further study and collaborative effort. The informal exchange of ideas characteristic of such meetings enables counterpart professionals to bridge political and cultural differences and understand each other's perspectives.

The American delegation was selected on the basis of specialization and the agenda comprised delegates' specific professional objectives. Biographies and suggested subjects for discussion and presentation were provided to CMES, which laid groundwork for effective dialogue.

Our delegation visited the four key cities of Beijing, Shenyang, Hangzhou, and Guangzhou to study problems facing Chinese engineers and managers and learn how they are coping (see Figure 1). We shared expertise and experiences at formal meetings, group discussions, site visits, and informal gatherings. We gained insights into current practices and planned future directions of engineering management in China and gained a clearer picture of the Chinese people and their culture.

教育

HISTORY

In the third millennium B.C., neolithic cultures flourished in what is now known as China; however, specific sites have not been linked to early heroes described by Chinese historians. The powerful Chinese dynasties (families of rulers) existed from the earliest period until 1912, when China became a republic (see Figure 2). Historians believe the **Xia** (Hsia) Dynasty held forth from about 2200 to 1700 B.C. This was followed by the **Shang** Dynasty until 1100 B.C. when historical records begin to coincide with archaeological records. Many sources now show happenings of the **Zhou** (Chou) Dynasty, 1100-221 B.C. that followed. Confucius, a foremost philospher, lived from 551-479 B.C. during the **Zhou** Dynasty. He was an aristocrat and achieved position by advising the upper class how to behave, emphasizing preservation of tradition and moral cultivation. Moral prestige, he taught, gave one influence over people. Confucius was convinced when a prince's personal conduct is correct, his government is effective without issuing orders; if a princes's conduct is incorrect, orders will not be followed. In 221 B.C., after centuries of warfare between competing states, China was unified by **Qin**, the westernmost state. China first became known to the West during this period because of the silk from Qin and authorities believe this is how the word China evolved.

When the emperor died, a struggle for leadership ensued. The victorious regional commander Liu Bang, founded the **Han** Dynasty in 206 B.C.

The **Han** Dynasty ruled for the next four centuries, except for the period from 9-23 A.D. when **Wang Mang** usurped the throne and declared his dynasty. The period before **Mang** is sometimes referred to as the **Former Han** and the period after **Mang** (25-220) as the **After Han.** Following abdication of the last **Han** emperor in 220, each of the three warlords who opposed him proclaimed himself ruler. This began what is known as the **Three Kingdoms Period** (220-265).

After some stressful years, the **Jin** (Chin) Dynasty succeeded in unifying China in 280. This display of strength was only temporary. The northern non-Chinese tribes posed a threat, and in 311 the **Jin** Dynasty lost its capital and the court had to flee to the relatively undeveloped area south of the Yangtze River. **Northern** and **Southern** Dynasties then ruled independently for nearly three centuries. During this period, the new religion of Buddhism found a receptive audience. The north-south geographic division was unstable, until the **Sui** Dynasty in the north defeated the southern dynasty of **Chen** in 589 and unified the north and south. The **Sui** Dynasty maintained control until 618, when the **Tang** Dynasty was founded. In the mid-ninth century, this early imperial dynasty was destroyed by ambitious generals. After demise of the **Tang** Dynasty in 907, there were five short-lived dynasties. The last one was overthrown by the **Song** (Sung), who ruled from 960 to 1279.

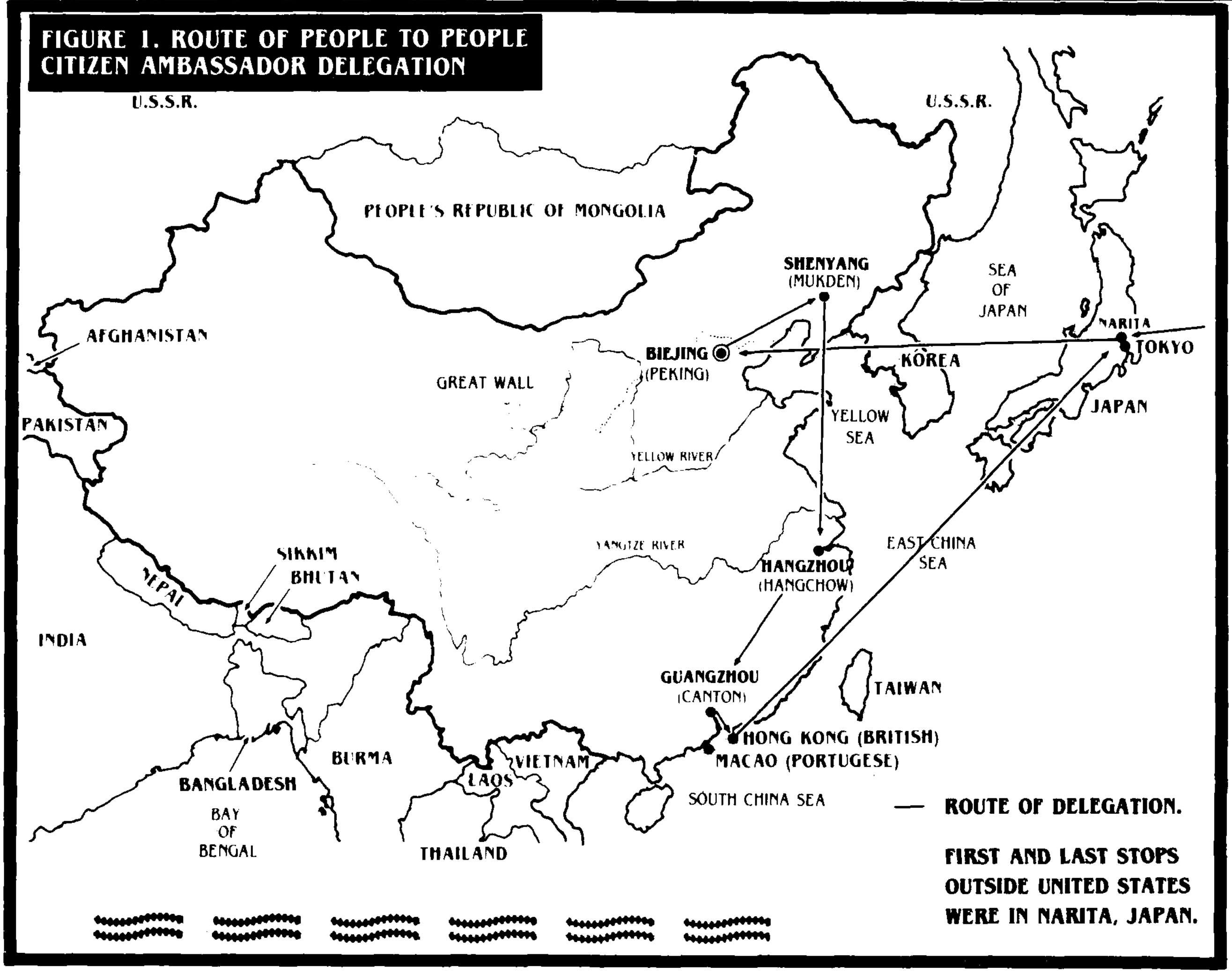
Under the **Yuan** (Mongol) Dynasty (1279-1368), which followed the **Song** Dynasty, intellectual, literary, and artistic pursuits thrived. But, peasant rebellions and internal weaknesses brought this dynasty to an end.

In 1368, the **Ming** Dynasty was established. It lasted until 1644. During that period (in 1421), Beijing (Peking) became the capital. Except for a few brief periods, Beijing has remained the capital of China. The **Ming** Dynasty is viewed as one of the most prosperous periods in China's history. It was the first autocratic dynasty. In the mid-1600s, as happened to others in times past, the **Ming** Dynasty was overthrown by rebellious peasants.

PEOPLE TO PEOPLE

Opinions, conclusions, and recommendations expressed or implied in this report are solely those of the author and do not necessarily represent the views of the Defense Systems Management College, the Department of Defense, or any other government agency.

FIGURE 1. ROUTE OF PEOPLE TO PEOPLE CITIZEN AMBASSADOR DELEGATION



The new **Qing** (Ch'ing or Manchu) Dynasty was founded in 1644 by a non-Chinese tribe in Manchuria. Traditional scholarship and arts flourished and basic literacy was relatively high. The traditional Chinese civilization was undermined by a steady population growth. The government structure could not cope with the pace of the growth and in 1912, the dynasty was overthrown in a military uprising. Instability and restiveness pervaded most segments of the society.

The decades from the end of the **Qing** Dynasty until the founding of the People's Republic of China in 1949 are identified by historians as the Republican Period. Monarchy was repudiated, and the Western theory of a constitutional republican government was honored but seldom practiced. Chiang Kai-shek, establishing the National Government of the Republic of China in 1927, saw troubles to develop between his government and the Communists and war began in 1946. Communist forces, helped by the Soviet Union, fought and defeated the Chinese National Government. In 1949, Mao Zedong, leader of the Communist forces, became head of the country. Chiang and his army fled to Taiwan and a few small islands off mainland China. He died in Taiwan in 1975, 4 years after the People's Republic replaced the National Government in the United Nations.

When the Communists came to power Oct. 1, 1949, date of Chinese liberation, Chairman Mao Zedong referred to as Mao, proclaimed the birth of the People's Republic of China at the Gate of Heavenly Peace in Beijing. In January 1950, Great Britian resumed diplomatic relations.

In 1953, the first Five-Year Plan was introduced, attempting to develop the Chinese economy. Although experiencing setbacks since then, for the most part the Chinese have been moving toward relative prosperity and freedom.

China, principally an agrarian society, is about 80 percent agricultural; therefore, one of the early thrusts of Mao was a land-to-peasants program, which didn't work well. Mao tried collectivism, communes, and communes with private plots. During the Great Proletarian Cultural Revolution, which began in 1964, communes with private plots were abolished, only to be reinstated later. It was apparent by the ear-

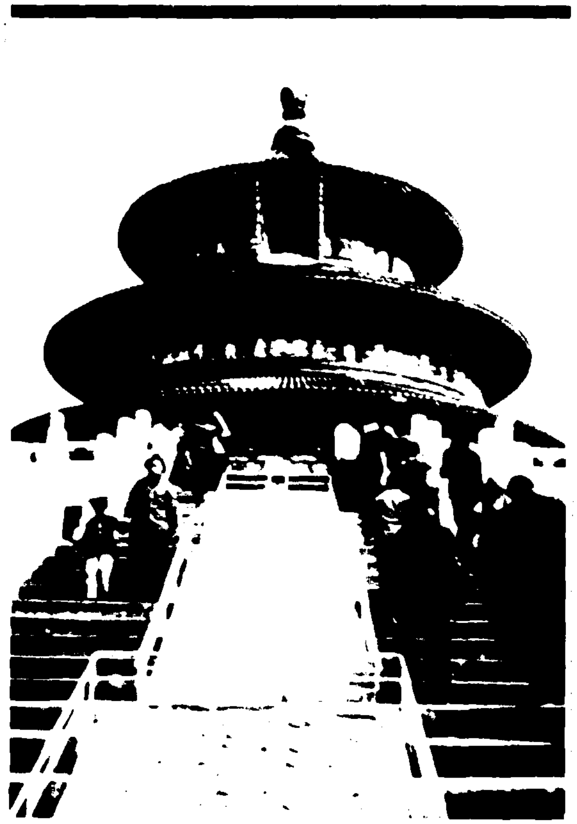
ly 1970s that Mao's reform attempts did not meet the people's needs.

In 1972, President Nixon made a historic visit to China, beginning a good relationship between the United States and the People's Republic. After the deaths of Mao Zedong and Zhou Enlai in 1976, the international relationship continued, and, in 1979, the United States and China established formal diplomatic relations.

About 1977, the catch words became *Four Modernizations*; that is, modernization of agriculture, industry, science and technology, and defense. To accomplish these modernizations, it was generally recognized that measures must be taken to control population at an appropriate level; if not done, the modernizations would be undermined.

To realize the modernizations, there had to be a large accumulation of capital; on the other hand, the people's standard of living had to be improved. To satisfy both needs, China had to expand production and practice strict economy. Also, the Chinese had to curb population growth, which was important in managing the relationship between accumulation and consumption. Through population control it was expected scientific and cultural levels would rise.

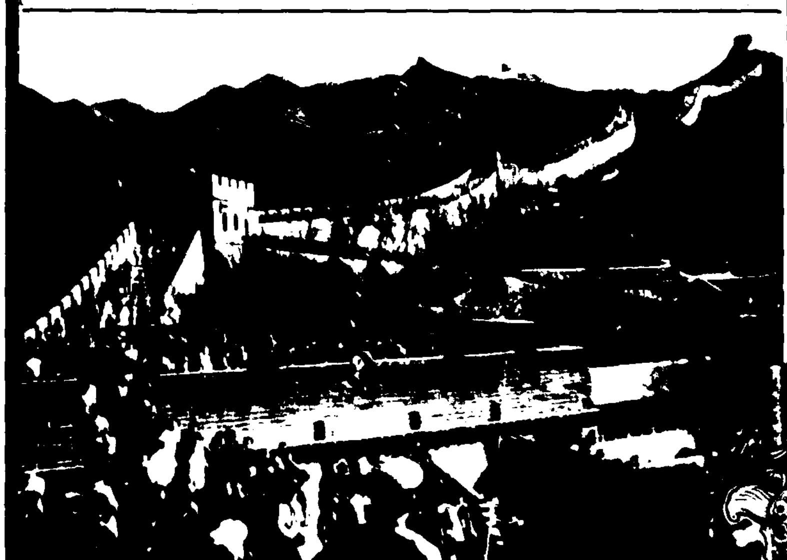
In 1981, an economy based on the family as the economical unit replaced communes. Chinese officials admit, at least privately, that Mao made mistakes. Today, rural inhabitants rent land and farm



Hall of Prayer for Good Harvests, Tiantan Park, Beijing

Photographer: David D. Acker

The Great Wall



machinery. The government receives an agreed-upon share of farm produce; villagers sell the surplus. People can work on projects, whether handicrafts, vegetable growing, or livestock raising; people can sell crafts, produce, etc., in free markets for gain. Using the present economic system, the government no longer tells people what and how much to produce. Peasants work hard and some earn higher incomes than salaried city dwellers.

Generally speaking, the Chinese are pragmatists, tending to take a short-sighted approach to problem-solving; when something fails, they try another approach. For example, they removed trees in the capital city of Beijing because they attracted bugs. They discovered later that birds left because trees were removed; recognizing the mistake, the people are replacing the trees.

Another recent change is that families and other groups are opening factories, hotels, and restaurants.

For the first time, less than 50 percent of income in villages results from agriculture, which is becoming more mechanized. Growth of urban areas with new factories, schools, resorts, airfields, and golf courses will cut into agricultural areas. Slogans of nationalistic self-sufficiency and personal sacrifice, in vogue during Mao's leadership, gave way to modernization and international cooperation. Foreign investment is encouraged.

The Chinese enjoy more freedom and life is taken less seriously. They take tours and visit foreign countries. After decades of drabness, China is sprucing up.

FIGURE 2. CHRONOLOGY OF CHINESE DYNASTIES AND REPUBLICS

XIA (HSIA) DYNASTY	**c. 21st—16th CENTURIES BC**
SHANG (YIN) DYNASTY	**c. 16th CENTURY—1100 BC**
ZHOU (CHOU) DYNASTY	**c. 1100—221 BC**
WESTERN ZHOU (CHOU)/c. 1100—771 BC	
EASTERN ZHOU (CHOU)/770—256 BC	
SPRING AND AUTUMN PERIOD/722—481BC	
WARRING STATES PERIOD/403—221 BC	
QIN (CH'IN) DYNASTY	**221—206 BC**
HAN DYNASTY	**206 BC—220 AD**
WESTERN HAN/206 BC—23 AD	
EASTERN HAN/25—220	
THREE KINGDOMS PERIODS	**220—265**
STATE OF WEI/220—65	
STATE OF SHU/221—63	
STATE OF WU/222—80	
WESTERN JIN (TSIN) DYNASTY	**265—316**
EASTERN JIN (TSIN) DYNASTY AND SIXTEEN STATES	**317—439**
EASTERN JIN (TSIN)/317—420	
SIXTEEN STATES/304—439	

人口

POPULATION

One in five persons in the world is Chinese. The population of China is about 1 billion, 50 million; half the population is less than 31 years of age; life expectancy is 68. By the end of this century, China aims to stabilize its population at 1.2 billion; to do so, women in the cities must wait until they are at least 25 before marrying, and men until they are 27 or 28. Figure 3 shows population growth since the People's Republic of China was established in 1949. Every hour, population increases by about 1,375 people; in one year, it increases by about 14 to 15 million.

The *family planning program*, making one-child families the norm, began in 1979 and, since 1981, has been enforced with increasing toughness. The target population growth rate of 1 percent is being attained in major cities, but not in rural areas. Last year, births exceeded the target by 1 million, 600 thousand; thus, the government introduced incentives limiting the number of children per family. Parents limiting themselves to one child receive bonus payments, high pensions, and preferential housing treatment; parents who don't risk pay cuts, reduced medical care, and special taxes. After bearing one child, a pregnant women is urged to abort. There are about 35 million children resulting from this one-child policy. A 4-2-1 syndrone has developed: four adoring grandparents, two indulgent parents and one spoiled child. Chinese officials are granting special status to families with only one child. These families are promised future housing and work assignments. There are indications that the one-child policy may be relaxed because it has sparked resentment.

彼此相顧

HEALTH CARE

Health has improved since 1949. There are about 67,000 hospitals with 21 million beds and 135 million doctors, an average

SOUTHERN AND NORTHERN DYNASTIES	**386—589**
SOUTHERN DYNASTIES	
LIU SONG (SUNG)/420—79	
QI (CHI'I)/479—502	
LIANG/502—57	
CHEN (CH'EN)/557—89	
NORTHERN DYNASTIES	
NORTHERN WEI/386—534	
EASTERN WEI/534—50	
NORTHERN QI (CH'I)/550—77	
WESTERN WEI/535—57	
NORTHERN ZHOU (CHOU)/557—81	
SUI DYNASTY	**589—618**
TANG (T'ANG) DYNASTY	**618—907**
FIVE DYNASTIES AND TEN KINGDOMS PERIOD	**907—960**
LATER LIANG/907—23	
LATER TANG (T'ANG)/923—36	
LATER JIN (TSIN)/936—46	
LATER HAN/947—50	
LATER ZHOU (CHOU)/951—60	
TEN KINGDOMS/902—60	
SONG (SUNG) DYNASTY	**960—1279**
NORTHERN SONG (SUNG) 960—1126	
SOUTHERN SONG (SUNG) 1127—1279	
YUAN (MONGOL) DYNASTY	**1279—1368**
MING DYNASTY	**1368—1644**
QING (CH'ING OR MANCHU) DYNASTY	**1644—1911**
REPUBLIC OF CHINA	**1912—1949**
PEOPLE'S REPUBLIC OF CHINA	**ESTAB. 1949**

ETHNIC GROUPS

China has 56 ethnic groups. Han Chinese being the largest group with 93 percent of the total population; seven percent are national minorities and reside in two-thirds of China's total area. The Uygurs and Hui live in the northwest; Hui, Mongols, Koreans, and Manchus in the north and northeast; Zhuangs and Maios in the south; and Tibetans in the west and southwest.

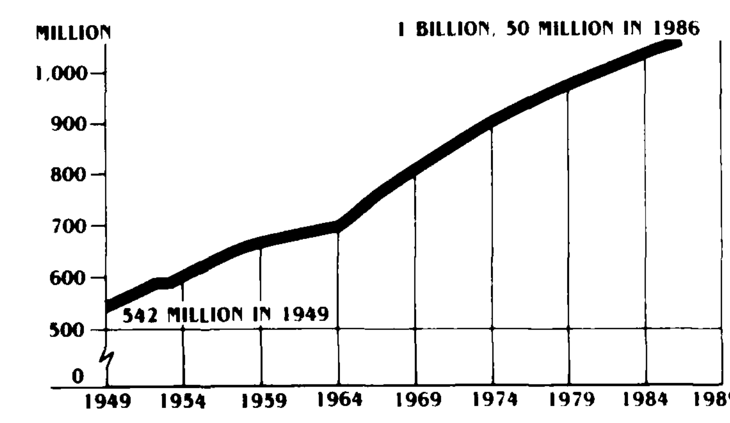
LANGUAGE

When the Communists came into power in 1949, Putoghua became the national language of China. Sometimes referred to as Mandarin, it is based on the Beijing dialect and is the only modern language written entirely in non-phonetic ideographs. In 1979, China adopted the pinyin system of romanizing its language and based it on the Beijing pronunciation. This was a difficult decision because the Chinese character is monosyllabic; each syllable has three elements—beginning sound, a final

of 207 hospital beds and 133 doctors for every 1,000 people. About 90,000 doctors have advanced degrees. The restructuring of the health care system after the Cultural Revolution has benefited people living in the cities and countryside. Four 6-year medical programs provide studies at a higher level; 3-5 year programs provide medical education. In Beijing and Tianjin, nursing science degree programs began recently. There are plans to upgrade nursing science education elsewhere.

China is acquiring highly technical equipment. Sometimes, new medical equipment remains on show or is unassembled because the staffs don't know how to assemble, use, or repair it. With emphasis on modernization and medical technology rather than patients, well-qualified professionals emphasizing total patient care are assets in today's China.

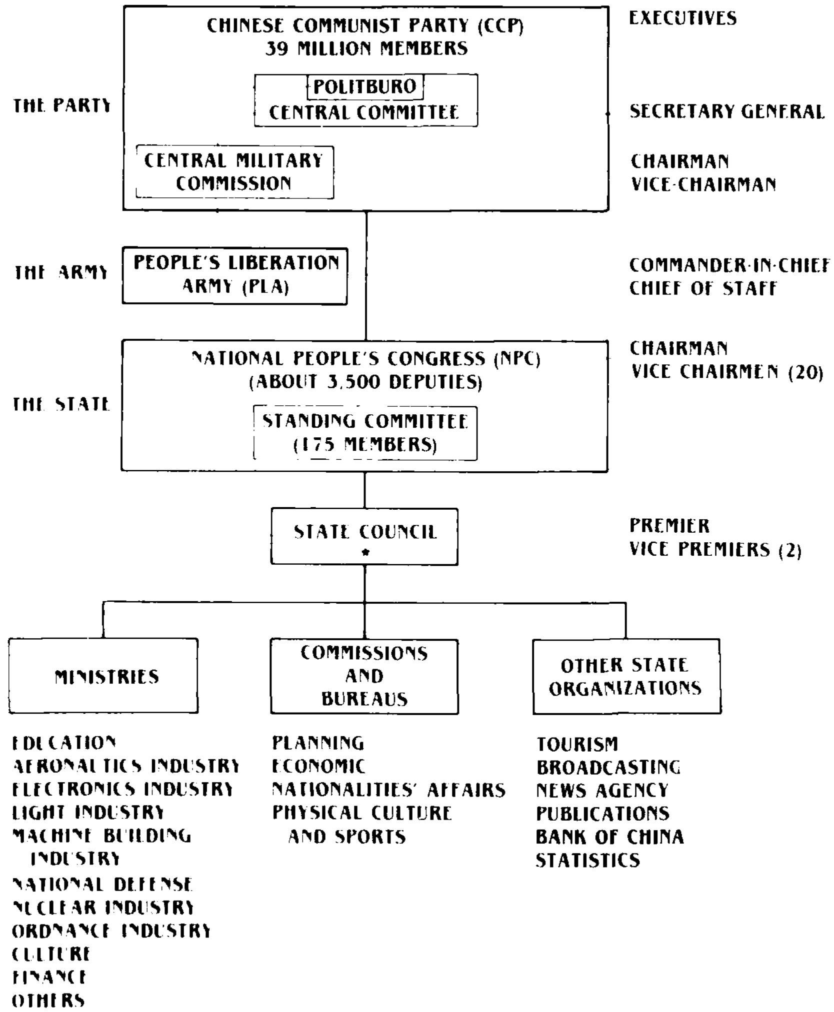
FIGURE 3. POPULATION GROWTH SINCE THE CULTURAL REVOLUTION



PROJECTED POPULATION AT END OF CENTURY: 1 BILLION, 190 MILLION

BASIC DATA: PEOPLE'S REPUBLIC OF CHINA. POPULATION REFERENCE BUREAU

FIGURE 4. DISTRIBUTION OF POLITICAL POWER



* THE STATE COUNCIL, APPOINTED BY THE NPC ON THE ADVICE OF THE PARTY CENTRAL COMMITTEE, COMPRISES:

- PREMIER
- 2 VICE-PREMIERS
- 41 MINISTERS
- OTHER GOVERNMENT LEADERS

sound, and tone. The word **ma** can have four meanings depending on the tone of voice used; i.e., mother, hemp, horse, or to scold.

New Chinese literature published in English uses the pinyin system; however, many historical names can be found in the older form of romanization. I have used the pinyin system and, in the case of a name of a person or place you may more readily recognize the old form. I show it in brackets immediately following the new form.

EDUCATION

Educational benefits which resulted from the establishment of the People's Republic have been great. Before 1949 more than 80 percent of the population could neither read nor write. Today, through adult education programs, more than 90 percent of the Chinese can do so.

More than 210 million Chinese students are enrolled in 164,000 kindergartens; 900,000 6-year primary schools; 160,000 6-year middle schools (3 years junior level and 3 years senior level); and 1,054 schools of higher learning (271 devoted to science and engineering). Two percent of Chinese youth enter college compared with 40 percent of American youth. Almost 600,000 graduates apply for the 8,500 openings available in post-graduate education.

Beginning in 1978, college admission was based on standardized entrance examinations and academic criteria, rather than on political criteria. Until recently the government decided, usually by examinations, who would be paid to go to college and where graduates would work after completing courses. In some new colleges, students pay their fees, choose subjects, and find jobs after graduation. Thousands are encouraged to study abroad. A small but growing number of foreign students go to China to study.

In 1986, 6.9 percent of the university graduates received state-selected posts.

RELIGION

As indicated, the Chinese people are pragmatic. They tend to worship gods they feel will answer their prayers. Although China is an atheistic country, it tolerates many religions. It is not unusual for a person to support several churches and temples. This approach is used by young Chinese because their elders teach it is one's duty to keep ancestral spirits happy.

Historians credit the Scottish missionary, Robert Morrision (1782-1834), with taking the gospel to China. He arrived in 1807 and in 12 years, prepared the first Chinese-English dictionary and translation of the entire Bible.

After the first Opium War in 1844, missionaries to China were protected by a series of treaties. Between 1860 and 1900, there was a phenomenal growth in missionary outreach, especially into inland China. In 1900, during the notorious Boxer Rebellion, 189 missionaries and their children were put to death and a greater number of Chinese Christians were killed. After the 1911 revolution brought an end to the **Qing** Dynasty, Christianity flourished. After liberation in 1949, Roman Catholic bishops opposing Chinese leaders were jailed or escaped to Taiwan and ties with the Vatican were severed.

During the Cultural Revolution (1966-1976), religion was one of the major targets for elimination. Churches and temples were closed or destroyed by Red Guards, and believers were arrested and imprisoned; tablets with names of ancestors and descriptions of important family events were destroyed; church buildings were converted into apartments, factories, or storehouses. After the fall of the Gang of Four, the Chinese government encouraged the rebuilding of churches and temples and, today, the Chinese constitution permits freedom of belief.

Today, there are 4 million Christians in China and more than 200 churches have open meetings. The Muslims, who were organized in 652 A.D. during the **Tang** Dynasty, now number about 15 million. Hundreds of mosques, as well as Buddhist and Lamaistic temples and pagodas, are open for worship. Clerical training and domestic publication of Bibles, hymnals, and other religious documents are permitted.

地理

GEOGRAPHY

China, third largest country in the world in total area (about 3,760,000 square miles), is nearly as large as the European Continent. Only Canada and Russia exceed it in area. See the China map (Figure 1).

China, located between the Siberian Steppes in the north and tropical jungles in the south, has a 14,000-mile border, 4,500 miles of which are shared with generally hostile countries. To the west is a vast desert and a high plateau, and to the east is the nearly 2,500-miles-long coastline. Ninety percent of the Chinese live in 17 percent of the area, the fertile plains and deltas of the east. Only 10 percent of China's area is cultivated because 67 percent is mountainous or semi-desert. The two principal rivers are the Yellow and the Yangtze. The Yangtze in central China has a larger discharge than the Yellow River in the north and it is longer; flow rate of the Yangtze is the third largest in the world. The Pearl in the south can accommodate ocean-going vessels.

治理

GOVERNMENT

The People's Republic was established on Oct. 1, 1949, and the present constitution became effective in 1982. Government organization is diagrammed in Figure 4.

The country is divided into 21 provinces, five self-governing autonomous regions harboring national minorities (Inner Mongolia, Kwangsi, Ningsia, Sinkiang, and Tibet), three municipalities (Beijing, Shanghai, Tianjin), 174 prefectures, and about 2,200 counties. Shanghai (population 11 million) is the largest city and 15 other cities have populations exceeding 1 million.

The political power is distributed among three organizations: the Communist Party, the State, and the Army.

Below: Chinese Woodcut
Courtesy Rita Aero **Things Chinese.**

The 44-million-member Chinese Communist Party (CCP) exercises control and leadership of the country. The State Council is subordinate to the Party which establishes policy that is implemented by the council. Key government positions are held by Party members.

The Party, the real power in China, controls the Army through the Central Military Commission. Although the State can speak on military affairs through the Minister of Defense, the real power resides with the commission.

Party leaders are compelled to rule by building consensus for new policies among members of the CCP and the population at large because of China's vastness and the social diversity. Party control is tightest in government offices and in urban economic, industrial, and cultural settings; it is looser in rural areas where almost 80 percent of the people live and work.

There are eight minor parties with no influence.

Local people's governments have replaced revolutionary committees which lost favor when the Cultural Revolution ended. These local governments, introduced in 1980, carry out decisions of the people's congresses at the corresponding levels and the orders of the state administration at higher levels.

The head of the Central Military Commission is the Commander-in-Chief of the Armed Forces. He emphasizes political training in the armed forces.

The Chinese People's Liberation Party (PLA) was begun 60 years ago, Aug. 1, 1927. Poorly equipped and dubbed an army with "millet and rifles," its aim was to liberate the people and safeguard China's independence; therefore, it won the support of the people. In recent years the PLA made a strategic shift, changing its guiding thought from preparedness against an early full-scale and nuclear war to normal military construction in peacetime.

In 1985, the PLA began a reduction of its forces from 4 million to 3 million. This has been completed. Popularity of the PLA today probably rests on its cooperation with, and support to, civilans in harvesting crops, reclaiming land, and flood control.

The State Council is the executive branch of the National People's Congress (NPC) headed by a premier supported by 3 or 4 vice premiers. Vice premiers are generally senior members of the Politburo. The State Council and its Standing Committee coordinate the work of 41 ministries, the commissions, bureaus, and other state organizations.

The NPC is theoretically the highest organ of state power; however, it has less power than the State Council. It comprises deputies elected by the people's congresses of the provinces and municipalities, directly under Central Government Control by the people's congress of each autonomous region and members of the People's Liberation Army. There are about 3,500 NPC deputies. Principal actions of the NPC take place in the Standing Committee of 175 members. The NPC meets annually for about 2 weeks when it reviews and passes major new policies and laws, and the budget. It directs major changes in personnel. The NPC is not an active body and its decisions are token in nature. Decisions reflect confirmation of policies adopted elsewhere. To help preserve the appearance of popular participation in government, the Chinese press gives considerable importance to the activities of the NCP.

The budget of the central government is about $60 billion per year. Revenues and expenditures are almost in balance. The defense budget is about 8 to 9 percent of the Gross National Product (GNP) which is more than $300 billion annually. The annual rate of growth is more than 7 percent and the average rate of inflation is about 2 percent.

China's leaders are striving to develop a legal system to prevent recurrence of the unchecked exercise of official authority and the revolutionary excess of the Cultural Revolution. Launched by Party Chairman Mao, this revolution resulted in political and social anarchy lasting for about 10 years; no new buildings were erected, and law schools were closed. Today, new homes, apartments, offices, and factories are being erected everywhere. Law schools are open. The Chinese government is committed to expanding legal training.

經濟學

ECONOMY

Economy. In 1949, when the People's Republic was established, China's economy was suffering from severe dislocations caused by war and inflation. The new government was concerned with consolidating power, restoring public order and eliminating widespread unemployment and starvation. As I said, with most of these problems resolved in 1953, the Chinese government launched its Five-Year Plan. Concerned about national defense, the Plan centered upon a rapid build-up of heavy industry. Agriculture received a small investment by the state. By the end of the first Five-Year Plan, the economy was averaging a 6.4 percent growth per year. This was accomplished despite poor planning and political turmoil.

In 1958, the second Five-Year Plan was launched, as the "Great Leap Forward," an attempt to attain enormous economic growth rates. Industrial and rural areas were reorganized into communes. There was an attempt to bring about large increases in industral production and in agriculture. Many industrial targets were reached, but were accomplished by sacrificing product quality. In agriculture, reorganizing peasants coincided with bad farming seasons and food production dropped dramatically. In 1962, the government was forced to reorganize the communes into smaller, more effective communities. Furthermore, the split between China and the Soviet Union came into the open. The dispute led to the withdrawal of Soviet experts from China.

The Sino-Soviet dispute in the early 1960s and the Great Leap Forward disrupted the economy. Ideology was injected into economic planning. The educational system was damaged and foreign trade was interrputed. Red Guards traveled around China taking part in revolutionary movements and destroyed religious statues, buildings, and ancestral tablets. They opposed old virtues like long life, happiness, and personal wealth. They renamed streets and parks.

The third Five-Year Plan (1966-1970) was launched after a delay of 3 years. The Great Proletarian Cultural Revolution burst upon the scene in 1966 and caused industrial chaos; however, production in the agricultural section was not disturbed for the most part. The Cultural Revolution placed emphasis on raising the political consciousness of the people at the expense of production. The campaign split the Party. By 1967, industrial production had dropped by 15 percent from the previous year. The targets of the third Five-Year Plan were not met.

The fourth Five-Year Plan (1971-1975) gave support to agriculture as the basis of the economy. It stressed mechanization of agriculture and it emphasized that development of the economic infrastructure, transportation, electrification, development of the mining industries, and expansion of the iron, steel, and petrochemical industries. This was China's most successful plan.

The fifth Five-Year Plan was due to commence in 1976. It was delayed because of internal struggles in the CCP. During that year Zhou Enlai and Mao Zedong died. Acting premier Deng Xiaoping was dismissed. The "Gang of Four," vanguard of a radical movement, were arrested and deposed.

Subsequently, the fifth Five-Year Plan was replaced by the first Ten-Year Plan, which was to run from 1976 to 1985. The plan called for the Four Modernizations. However, the plan was scrapped and was replaced by a new Five-Year Plan to bring the country through to 1985. A strategic shift was made in resources allocation from investment to consumption, and from producer goods to consumer goods. Better living conditions rather than rapid industrial growth was fostered, with increasing concern for market forces, greater management autonomy, and decentralization.

The seventh Five-Year Plan (1986-1991) is emphasizing continued growth through expansion and modernization of existing plants rather than through development of new facilities. Investment is being concentrated on the railways, harbors, power stations, and coal mines. Management reforms are needed to ensure the current economic plans succeed. The U.S. State Department spokesmen believe the prospect for success will be limited unless the Chinese government inaugurates a comprehensive program of price reform; one that will bring manufacturing processes in line with production costs and take into account relative scarcities in the economy.

The Chinese government has long favored a policy of "self-reliance." This involves restriction and diversification of imports and foreign credits to avoid dependence on specific sources; however, current Chinese leadership recognizes the need for foreign trade and technology to accomplish modernization goals. China is trading with more than 150 countries. Communist countries account for more than 90 percent of the foreign trade.

Although China's trade practices are conservative and cautious, the nation is moving rapidly toward greater economic interdependence with the industrialized nations of the West and, to a much lesser extent, with the Third World.

FIGURE 5. ORIENTATION OF FOREIGN INVESTMENT IN CHINA, 1979-86

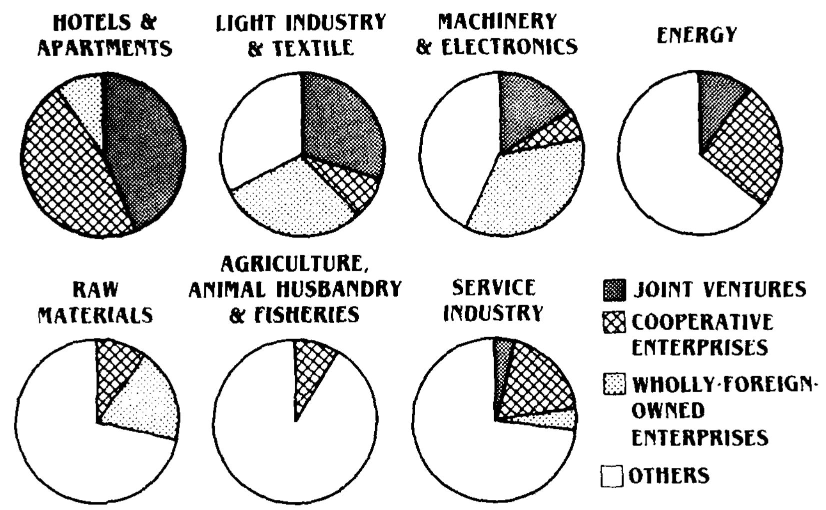
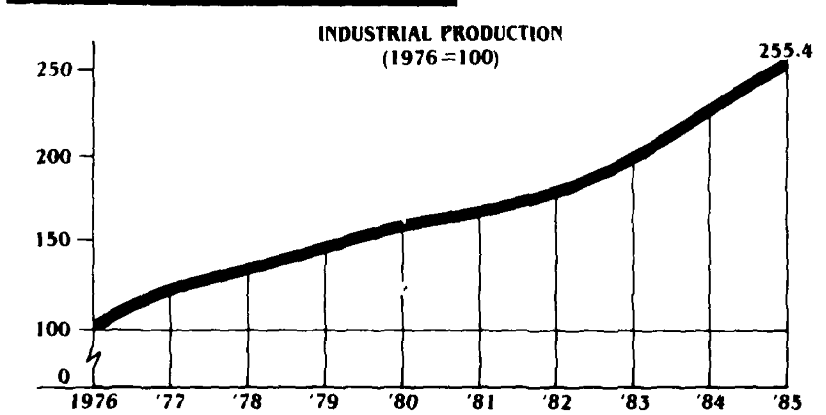


FIGURE 6. CHANGES IN ECONOMY ATTRIBUTED TO FACTORIES



NOTE: BASED ON CONSTANT 1980 YUAN VALUE AND EXCLUDING VILLAGE INDUSTRIES.

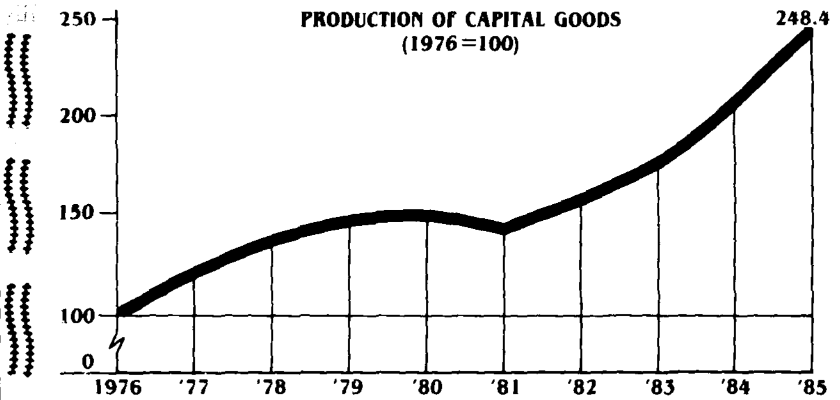
Between 1979 and 1986, China signed foreign loan agreements with the United States totalling $29 billion. More than 7,800 foreign investment contracts, totalling $19 billion, were established for equity on contracted joint ventures, wholly-foreign-owned businesses, and off-shore oil exploration projects (see Figure 5). By the end of 1986, about $3 billion in U.S. funds were pledged for 304 projects, representing 13.5 percent of the total foreign investment in China. To control the investment program, the Chinese government issued a document entitled "Provisions on the Encouragement of Foreign Policy," on Oct. 11, 1986.

China's economy is dominated by agriculture. More than 74.4 percent of the 450 million work force is engaged in agriculture, 15 percent in industry and commerce, and the remainder in other pursuits. The recent shift in focus of reform in China to the urban economy has brought prosperity to rural areas making the change to a commodity production economy possible. This, in turn, promotes a diversified economy of agriculture, forestry, fishery, and animal husbandry.

Increased farm production means cities will have to provide more industrial products, scientific and technological skills, and educational and cultural facilities to meet needs of the 800 million peasants. The peasants will need more motor vehicles to transport products to market; presently, there are four vehicles for every 10,000 people. With an annual automobile output of about 300,000, China cannot meet the demand for a long time (see Figures 6, 7, and 8).

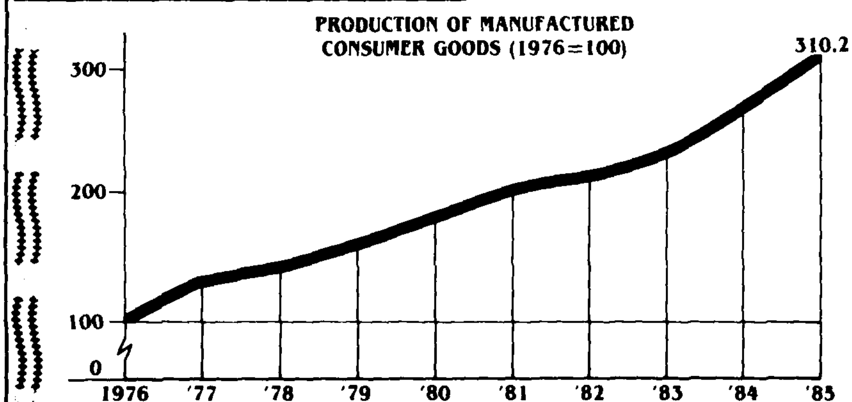
China's present reform does not mean there is a move afoot to abolish the socialist system. To the contrary, party leaders believe the reform will perfect the present system by transforming old and rigid economic patterns. Leaders believe the planned economy will be improved by guiding and regulating the entire national economy.

FIGURE 7. CHANGES IN ECONOMY ATTRIBUTED TO INDUSTRY

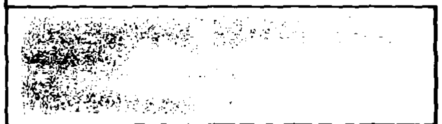


NOTE: BASED ON CONSTANT 1980 YUAN VALUE OF PRODUCTS SUCH AS MACHINE TOOLS, STEEL, POWER EQUIPMENT, TRUCKS.

FIGURE 8. CHANGES IN ECONOMY ATTRIBUTED TO CONSUMERS



NOTE: BASED ON CONSTANT 1980 YUAN VALUE OF GOODS SUCH AS BICYCLES, TV SETS, REFRIGERATORS, HOUSEWARES.



CONCLUSION

China, with the largest population in the world, is backward. Cultural and economic developments are uneven, transportation is not meeting people's needs, and information transmission is slow.

The government feels it has developed the economic plan needed for market forces to play a role in regulating production. The plan will enable the government to maintain a stipulated amount of materials to regulate production; at the same time, the government will use other economic means to activate the plan.

There will be a planned, national production of major products. Small commodities and services will be adjusted to meet market demands. Enterprises will have more decision-making power and be encouraged to exercise flexibility in management. China's leadership considers this to be a combination of overall planning and flexible management. ■

Endnotes

1. Clifford Geertz, "The Interpretation of Cultures," New York, 1973, p. 14.

2. Richard L. Armitage and Karl D. Jackson, "East Asia and the Pacific," *Defense/87*, May-June 1987, pp. 20-21.

DATA

A LOGICAL APPROACH TO ESTIMATE AT COMPLETION FORMULAS

Captain Jeffrey A. Totaro, USA

At the end of each month across the entire U.S. Government procurement environment in system project offices (SPOs), contract administrative offices, procuring contracting offices and military department-level centers, specialists charged with major procurement contracts review cost performance reports (CPRs), and cost/schedule status reports (C/SSRs). They prepare and review contract surveillance reports for higher headquarters. Among data surveillance typically accomplished in this cycle is an estimate at completion (EAC). The office preparing the report often gets input for the EAC from the contractor, who periodically does a "bottoms-up" latest revised estimate (LRE) of cost at completion and who is in the best position to estimate the status of the contract work.

Department of Defense engineers monitoring the program first-hand might have a different estimate of the contract completion costs than the contractor because they feel the contractor's LRE has not adequately discounted problems the engineer sees in certain work breakdown structure (WBS) elements. Sometimes, program management offices preparing contract performance reports, in addition to noting the contractor's LRE and government field engineers' adjustments to contractor's LRE, apply a mathematical equation to the figures on the CPR or C/SSR to arrive at a different EAC.

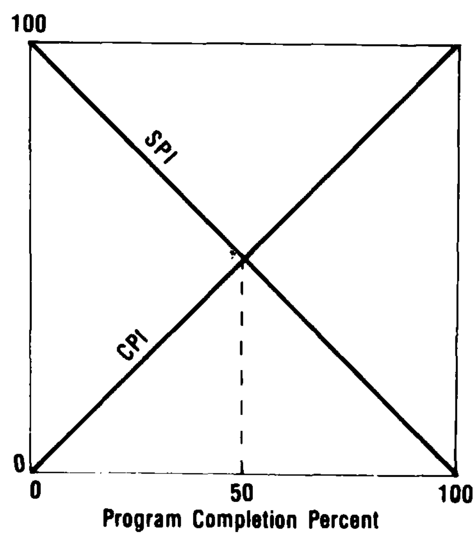
Many formulas are popular with government and contractor performance measurement specialists to accomplish the monthly task of updating the status of the contract. The Air Force Institute of Technology Cost/Schedule Control Systems Criteria course, SYS 362, exposes students to many of the formulas. In the "Information" text of the course, an excerpt from a thesis by Captain James B. Price, USAF, shows the historical validity of six methods for calculating EACs. He analyzed 57 research and development programs and by regression analysis showed that four of the six formulas were very good indicators of EAC. Course instructors poll the 30-40 students; some report their offices are using an EAC based on the Cost Performance Index (CPI). To review, the CPI = BCWP/ACWP. By far, the most popular formula in use today is the "composite performance index," which weights CPI and SPI. The SPI is the Schedule Performance Index (SPI = BCWP/BCWS). The two weightings seeming most popular are 75% CPI + 25% SPI and 80% CPI + 20% SPI. The formula for the latter is:

$$EAC = ACWP + \frac{BAC - BCWP}{.8\ CPI + .2\ SPI}$$

One SPI in the USAF Space Division, Los Angeles, uses a system that weights SPI 100% in the beginning of a program and straight-lines it to 0% at the end of a program. Figure 1 is a graph of this relationship.

It is easy to see why this Space Division SPO would heavily weight the SPI in the beginning of a contract if you realize the contract type it deals with—mostly research and development, some "pushing the envelope" of technology, with a few end-products toward the program's end. Suppose a contractor has begun a contract and finds he can not start on a portion of the statement of work even though he recently scheduled himself for that work in that time period. The SPO is concerned that the contractor planning to do the work realizes that, in fact, he can't. An EAC formula that heavily weights SPI in the beginning of a program will show poor schedule per-

Figure 1. Percent Weighting of CPI and SPI



formance quantitatively as a high EAC, reflecting a low measure of confidence in the ability of the contractor to estimate costs and schedule. This is a logical assumption for the SPO to make because that same contractor set up the schedule.

Some would argue that contractor problems would be reflected in the actual costs being assigned to the contract; in other words, the CPI. Usually, this is true. In an ongoing contract managed by the Santa Ana DCASMA, a program for the first 4 months reported CPIs of 90, 92.4, 99.1, and 103.2. Correspondingly, the EAC computed using the CPI looked as good. Obviously, a program without serious problems? Wrong! During those same first 4 months, it ran SPIs of 68.8, 37.5, 42.2, and 47. Only a formula that heavily weighted the SPI in the front part of the program would properly be addressing this lack of accomplishnent. Six months into the contract, the contractor admitted serious problems figuring how to do a portion of the statement of work. More funds had to be authorized by the PCO. The program, now 11 months old and 45% complete, has a CPI of 94.3 and an SPI of 67.8 (CPI and SPI measured against the new budget).

We have looked at the importance of SPI in the beginning of a contract. What about the end of a contract? There is some point toward the end of a contract where SPI becomes, for practical purposes, a meaningless number. The closer to the end of a contract, the less useful SPI is in telling government engineers how successful the contractor is because there is hardware produced, test reports that can be reviewed, and computer programs that can be evaluated against the design parameters. The later in a program, the less the engineers are concerned with the analysis of BCWS and the more they are concerned with evaluating the work produced. Government contract personnel cease to focus on SPI toward the end of a contract and worry more about the ACWP being charged against the contract until, finally, they are negotiating the final cost at completion, ACWP vs. the starting negotiated cost for the contract (Contract Budget Base). In other words, the CPI is their only concern. An exception, of course, are programs with clauses linking an additional fee for above-minimum performance for end-items produced.

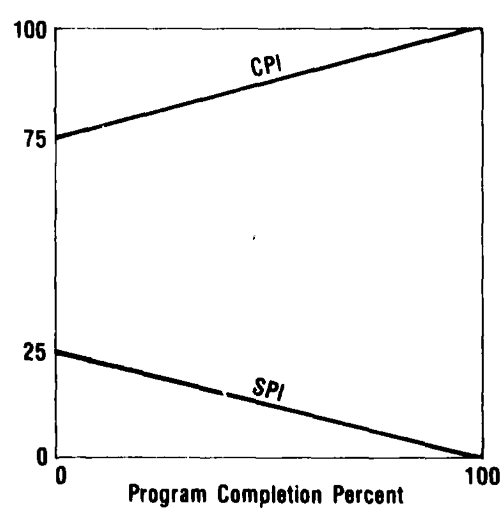
The logic of a weighting of 0% for SPI and 100% for CPI at contract completion should be easy for anyone to accept. What about at the start of a program? We made an argument for a 100% SPI weighting at contract start, but is this appropriate in all cases? Let's look at a hypothetical case.

Suppose the Acme Widget Corporation, which has made 5 types of widgets for the past 30 years, signs a government contract to provide 50,000 widgets of Type A to the government. Because of current heavy Type B production in the scheduled first month of the contract, Acme doesn't get the production line changed over to Type A until later in the month than scheduled. Consequently, the BCWS is larger than BCWP on the first C/SSR and, therefore, a low SPI is reported. Would it be appropriate to evaluate the EAC using a formula that heavily weights the SPI? Probably not. Most probably, actual costs that are being charged to the contract vs. the BCWP (in, other words, the CPI) would be a better guess of the EAC, even at this early stage of the contract. Acme might have renegotiated labor rates with hourly workers or, perhaps, received a bad batch of material and is experiencing a higher material usage rate; therefore, higher costs per widget produced. In this case, this would be more useful to translate to the EAC than the 3-week delay in schedule start.

We might agree it is safe to generalize that a contract with little technological risk, one with minimum non-recurring engineering, one where the company has experience with the end-product of the contract, should weight CPI greater than SPI—even at the contract start. But, should the SPI weighting used in the Acme case be zero at contract start? A case can be made that SPI should never be completely discounted at the beginning of a contract. If the contract falls behind at the start, there should always be some uncertainty expressed in the EAC that costs of the contract may increase. There is always the time value of money, the possibility of higher material inventory costs that might be assigned to the contract, etc. In the Acme Widget case, a 100% weighting of SPI in the beginning of the contract would not be appropriate though the surveillance monitor, or program office, could easily justify a 25-50% SPI. If, after considering Acme's track record, they selected 25% SPI at contract start, the graph of CPI/SPI weighting vs. contract completion percentage would be as shown in Figure 2.

The formula that would give the appropriate % performance index at any stage of this contract would be:

Figure 2. Percent Weighting of CPI and SPI



$$EAC(\%PI) = \frac{BAC - BCWP}{(.25 - .25(BCWP/BAC))SPI + (.75 + .25(BCWP/BAC))CPI} + ACWP$$

Suppose at 40% complete the contract was running a CPI of .85 and an SPI of .95. The % Performance Indicator called by the above situation is:

$$\%PI = (.25 - .25(.4)).95 + (.75 + .25(.4)).85$$

$$\%PI = .15(.95) + .85(.85)$$

$$\%PI = .865$$

The mathematics of figuring the "%PI" takes a few extra steps and may seem like a lot; however, most offices use spreadsheet software programs to update contracts every month, and it is just a matter of setting up the formula in the beginning of the contract.

The few extra steps are worth the trouble when you realize the EAC your office gives to decision-makers on the program is only one of many "machined" EACs generated. Suppose you sent in an EAC different from other EACs provided by the SPO, contractor, DCAS, or other subset of the procurement world. What would happen? Most likely you would justify your number. If you used "80-20 CPI/SPI" or "Quarterly CPI" or other formula different from others, once you explained your method, no one would give your analysis a second thought. Government and contractor program managers would recognize it as a "school solution" and might think: "Even though it had good regression on 45 other programs, why should it apply to my special situation?" By intuitively choosing a starting CPI and SPI based on this particular contract and contractor (and recognizing that at the end of a contract CPI should be weighted 100% and SPI 0%), you have a point of departure to address your concerns with the program. If the formula makes sense to program people, government or contractor, more validity is likely to be placed in the ensuing EAC. In most cases, the EAC calculated with the above analysis will not differ much from other EACs. You are more confident of using the EAC number, no matter how it compares with other EACs, if the formula was arrived at due to the nature of *this* contract and *this* contractor.

How do you pick an arguable starting SPI for a particular contract? You don't want to guess because that brings the analysis back to "80-20" or "75-25" or "Quarterly CPI." There is no substitute for first-hand knowledge of the contract statement of work and the contractor's ability to perform the statement of work. If you are far removed from the contractor's location and have no expertise with the statement of work, there is one way to arrive at an arguable starting SPI for the %PI formula. For large contracts requiring submission of the Cost Performance Report, the contractor provides the information. That is not to imply that he would say: "If this schedule slips in the beginning it will show I didn't know what I was doing when I scheduled the work and, should this happen, costs will probably skyrocket." What he does in scheduling the contract is allocate resources among program support types, manufacturing people and engineering department, dollars being shown on Format 2 of the *CPR* and hours (or rather time) shown on Format 4 of the CPR. Most important, the contractor shows the extent those types of hours are in the front, middle or later portions of a contract. By looking at the extent to which the contractor has "frontloaded" the effort on a contract, an educated guess can be made of the schedule risk he is exposed to.

Take as an example the plot of actual Format 4 data from a large full-scale development contract that DCAS Region, Los Angeles, monitors, shown in Figure 3.

This is a rather heavily front-loaded Format 4. Obviously, most effort is in non-recurring engineering in the very early part of the program. What weighting of SPI did the surveillance engineer choose to use on this program? He selected .75 SPI at contract start. The equation for this %PI is:

$$\%PI = (.75 - .75(BCWP/BAC))SPI + (.25 + .75(BCWP/BAC))CPI$$

Why not use an SPI weighting of less than 75% at contract start? The Format 4 is heavily front-loaded. The peak of the manufacturing effort is soon after the peak of the scheduled engineering effort. The schedule is tight. The SPI is heavily weighted compared with CPI in the front-part because the danger is that the contractor will be unable to surge from a standing start of 75 man-months of effective accomplishment in month number one to 175 man-months of accomplishment soon thereafter. If there are schedule slips here, it might as well

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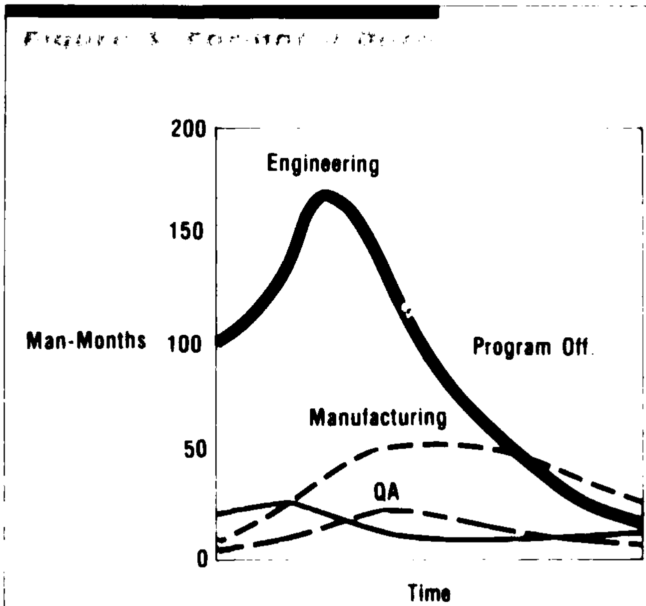


translate to a larger EAC because if the peak in the Engineer Format 4 curve flattens out it will probably mean a bigger area under that curve which translates directly to more cost. Schedule slips in the beginning will threaten the manufacturing schedule and if they have to "crash" for any of the design, it will mean much overtime or rework, or both.

Why not more than .75 SPI weighting at the start of the contract? This is a full-scale development contract. This contractor did research and development on the system. If technological risk was more of a factor, then SPI would be more weighted. The real question is not "Can they do it?" but, "Can they do it as fast as they plan to?" There is doubt. With the schedule and the possibility of cost problems crashing over the baselined-in design hump (large peak in the engineer Format 4 curve), CPI should be the dominant measuring stick of EAC by about one-third program completion (BCWP BAC). A SPI started at 75% weighting accomplishes this.

This analysis is one man s call and certainly more art than science. But if an EAC was generated by the above %PI formula for this program, who could argue with the logic or deny that engineer a hearing on his estimate of the program and his thoughts on corrective action.

Again, it is not recommended that a performance measurement specialist or engineer look to EAC(%PI) as the answer to the dream of having the way to do 100% accurate EAC calculations. The reason for advancing this EAC formulation is to have a system based on a logical approach tailored to a particular contract and a particular contractor. It is a point of departure to enable someone who sees a program problem to respond. In the performance-measurement world, program problems must be quantified into an EAC. What will be the government s final cost to do work as contracted. A formula serves the immediate quantification requirement. A formula based in logic can raise an arguable flag, calling for further analysis of the situation (particularly important to higher-level offices handling many contracts).

I chose five general categories of research and development and production contracts to display SPI CPI weighting choices that might be made in these situations; no attempt is made here to say all or any program should fit into one of these situations. Each surveillance monitor contractor, performance measurement specialist, or other program expert has to determine what the starting SPI weighting should be on a particular program. It is not my intent to dictate another "blind" methodology to use. The categorization below is offered to illustrate the thought process that could be used.

Situation 1. Heavily front-loaded Format 4. Technology being pushed one step beyond what it has been. More than 85% of BAC is assigned to engineering department. Might decide to use SPI weighting at 100% at contract start. Figure 1 shows slopes of SPI and CPI as contract work is completed. The formula for the %PI is:

%PI =
(1 - BCWP BAC)SPI +
(BCWP BAC)CPI

Situation 2. Somewhat front-loaded Format 4. Contractor must take technology a step beyond, but this contractor already has done that a few times in this field. More than 75% of the BAC is assigned to the engineers. Might decide to use an SPI weighting of 90% at contract start. Figure 4 graphically depicts this situation as contract work is completed. The formula for the %PI is:

%PI - O =
(.9 - .9(BCWP BAC))SPI +
(.1 + .9(BCWP BAC))CPI

Situation 3. Fairly level-loaded Format 4. Contractor has some experience with the design, perhaps now taking a previous R&D effort to full-scale development. More than 60% of the BAC is assigned to engineering. Might use a starting SPI weighting of 75%. Figure 5 displays the slopes. The %PI formula is:

%PI =
(.75 - .75(BCWP BAC))S- PI +
(.25 + .75(BCWP BAC))CPI

Situation 4. Format 4 is generally level, or even ramps up. The BAC assigned to engineering is not much more than that assigned to manufacturing. Contractor has some experience with end-products to be produced. You might use a starting SPI of 50%. Figure 6 shows the situation graphically. The formula for %PI is:

%PI =
(.5 - .5(BCWP 3.4C))SPI- +
(.5 + (.5(BC∧P BAC))CPI

Situation 5. Format 4 level, perhaps it ramps up slowly, then tails off. Engineering function has less than 30% of BAC. Contractor has much experience with the product. You might use

Figure 4. Percent Weighting of CPI and SPI

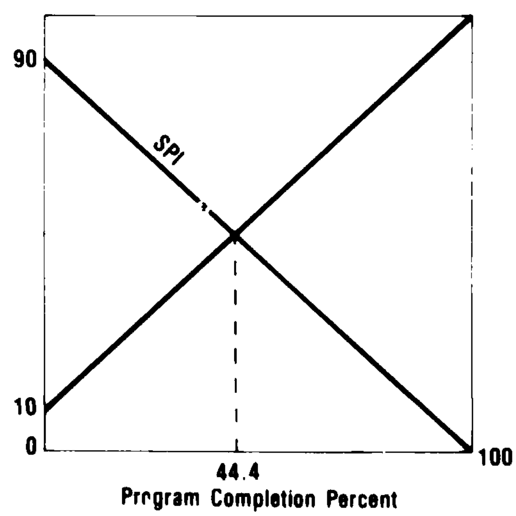
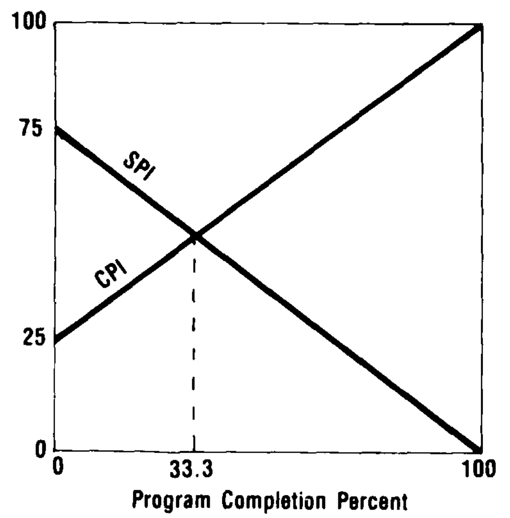


Figure 5. Percent Weighting of CPI and SPI



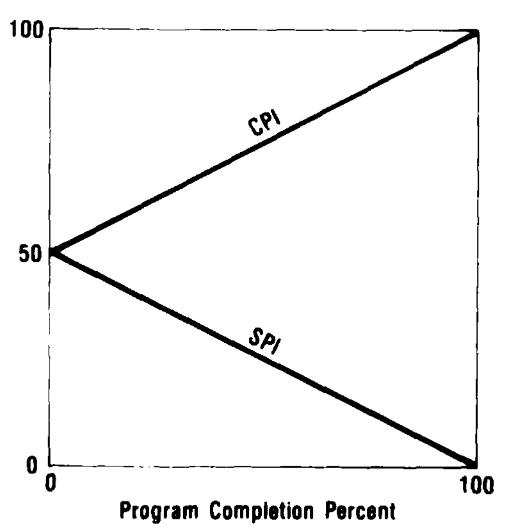
a starting SPI of 25%. Both the formula for this situation and the graph of weighting vs. contract completion were shown with Figure 2.

A few final notes on this discussion are in order to put in proper perspective what has been written here on this subject. As to EAC formulas, mention has not been made until now that in all EAC formulas you can choose to use the contractor's LRE in place of the BAC. You could also assume that management reserve will be used and, thus, use the Contract Budget Base. All considerations of these actions would be as appropriate with the EAC based on a %PI as any other, but a discussion of this is outside the scope of this presentation. Information that can be obtained from various formats of the CPR has been addressed. What about C SSR programs? Important in all programs, and especially important in C SSR programs, performance measurement specialists must realize that they do not have to live in a vacuum. The point is that if the information is not available from a Format 2 or 4, contractor master and or intermediate schedules, combined with government and contractor program office managers and engineer surveillance monitors, once consulted, can easily perform the same function. In fact, the more people in the "program review loop" who have input to the program progress measuring device (EAC formula), the more they will "buy into" the information the formula produces as the program goes on.

The data for six current programs being monitored by DCAS Region, Los Angeles, were checked at two time periods each (to evaluate different percentages of completion) that were treated with three different %PI to calculate an EAC. Zero percent completion SPI weightings of .9, .75, and .5 were used. In all cases, results were between the EAC(CPI) and the results arrived at using the best formula (by regression R-Squared) of Captain Price's thesis. This was expected due to the fact that the EAC(CPI) does not ever consider SPI and the other formula heavily weights the schedule variance as a constant percentage across the life of a program.

How important is this whole business of EAC formulation? When compared with continuous surveillance and government inspection of the data, hardware, and software products of a program and the government to contractor program manager interface to coordinate and reduce problems with development, test, and delivery, the "machined" EAC by itself is of very small significance indeed. It can be a useful device, especially early in a program, to give indication of the order of magnitude of problems in program cost and or schedule.■

Figure 6. Percent Weighting of CPI and SPI vs Completion Percent



Multisensor Water Analyzer

The Troop Support Command's Belvoir RDE Center has awarded a $343,073 contract for a new multisensor probe for an improved water quality analysis unit. It will replace the existing engineer set which is difficult to operate and resupply, and is designed to measure temperature, acidity, turbidity, dissolved solids and free available chlorine in less than five minutes. In operation, it will be used by water purification and preventive medicine teams during water point reconnaissance missions and water purification operations.■

T&E

TEST AND EVALUATION

Effects of Concurrency and Streamlining

Captain Robert Parkinson, USN

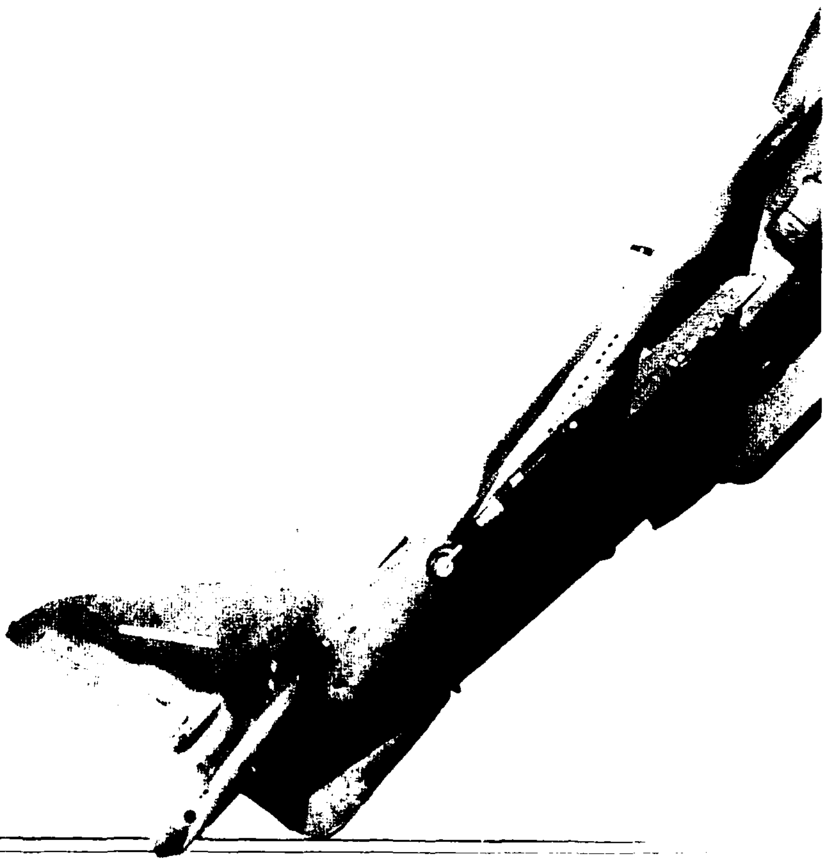
The first acquisition of a major weapon system for the U.S. Government started with the authorization for the procurement of six large frigates by the U.S. War Department in 1794. Seventeen months later six keels were laid but only three of the frigates were built due to schedule slippage and cost overruns.[1]

In more recent times, centering around World War II, the mode of acquisition was to develop, test, and produce aircraft almost simultaneously; resulting aircraft were delivered only to falter at the front lines with deficiencies that restricted full operational use. Subsequent to World War II, development models were phase tested followed by category testing; the U.S. Navy called category testing Navy Preliminary Evaluations (NPE). Operational test was to be included but faults were found in the approach to operational suitability testing.[2]

Of more concern, however, was acquisition concurrency between the production capacity build-up and the testing process. The result was production efficiency early in development but system deliveries occurred before completion of testing. Deficiencies found as the result of testing could not always be incorporated in the early production systems and restrictions on operations were placed on the aircraft as they were fielded.[3]

A 1970 study by a blue ribbon defense panel, which reviewed the acquisition process, recommended "appropriate planning early in the development cycle for subsequent tests and evaluations and effective transition to the test and evaluation phase"; also, "a general rule against concurrent development and production, with the production decisions deferred until successful demonstration of developmental prototypes."[4] From that study came the policy of determining operational suitability before production decisions, the so called "fly-before-buy" policy.

As a result, there was a significant increase in the length of the acquisition process because the development, test and evaluation, and production phases were directed to be in series instead of in parallel, or concurrent. Toward the end of the 1970s the Defense Science Board Summer Study, chaired by Dr. Richard DeLauer of TRW, Inc.,



brought this stretch-out into focus. Figure 1 shows the dramatic increase in the engineering man-days for just the contract design phase for some recent Navy ships.[5]

In 1980, Department of Defense Instruction 5000.2 included the statement, "Consideration (should be given to) acquisition cycle time by planned concurrency. This may include increasing funding, overlapping, combining or omitting the phases of the acquisition process or overlapping or combining developmental test and evaluation (DT&E) with operational test and evaluation (OT&E). The amount or degree of such concurrency should be keyed on the extent of the potential savings in acquisition time balanced against technical, cost and supportability risks and national urgency in each acquisition program".[6] The recent revision of DOD Instruction 5000.2 does not address the subject of concurrency[7] but it is well described in DOD Directive 5000.3.[8]

As there was growth in the length of acquisition, there was a parallel growth of government involvement in telling the contractors how to build as well as what to build. There was a tendency to expand scope of the references to specifications and standards in the solicitation process, the government providing those documents which often went into detail on how to build what the government was soliciting. Since the defense standardization and specification program (DSSP) was established in 1952 to improve the operational readiness and cost-effectiveness of defense material, there has been a growth to 45,000 active standardization documents today. Currently in support of the DSSP there are more than 7,000 standardization projects underway or planned.[9] A significant number of those standards and specifications are now references in the acquisition arena which dictate how industry is to build or make contract delivery items.

In 1981, Deputy Secretary of Defense Carlucci published 32 initiatives to improve the acquisition process. Two are having a significant effect on the test and evaluation of full-scale weapon systems. With the above background in mind, I address those two. The first is Number 12, "provide front-end funding for test hardware" and the second is Number 14, "reduce the number of DOD Directives." The rest of this paper concerns their impact on the acquisition of U.S. Naval Aviation weapon systems.

Concurrency

As mentioned, concurrent development test and production were occurring in the 1950s; today, concurrent activities focus on events of development that can be done in parallel such as development and operational testirg. Concurrency is not specifically defined in the guidance from the Department of Defense to its military service acquisition activities. Nevertheless, the program is clearly spelled out in DOD Directive 5000.3, last promulgated in 1986. In part it says:

> Combined Development Testing and Operational Testing (DT&E/OT&E): A combined DT&E and OT&E approach may be used when cost and time benefits are significant and are clearly identified, provided that test objectives are not compromised. Planning for such a testing approach shall be coordinated early during the test concept definition and designed so that resources are used efficiently to yield the data necessary to satisfy common needs of the developing agency and the Operational Test Authority (OTA). This requires that data bases be established and maintained to support progressive test and evaluation events during all phases of the acquisition cycle. Participation by the OTA in the planning and execution of tests must ensure that the testing conducted and data collected are sufficient and credible to meet the OTA's requirements. Any combined test program chosen shall contain enough dedicated operational test events to satisfy the OTA requirement for an independent evaluation. The final period of testing before the full production decision shall emphasize appropriate, separate OT&E managed by the OTA. In all cases, separate independent development and operational evaluations of test results shall be provided.[10]

Key aspects to this guidance are the provisions, "...the necessary resources, test conditions, and test data...." To meet these provisions necessary to support concurrent testing the program manager and staff must do a trade-off study between schedule and the cost of incorporating these provisions.[11] Obviously, for combined and/or concurrent test to occur, the ranges, weapons, test articles, data collection and reduction devices, aircrews and ground-support equipment must be available in sufficient quantities to permit simultaneous testing by development and operational testers. The reference

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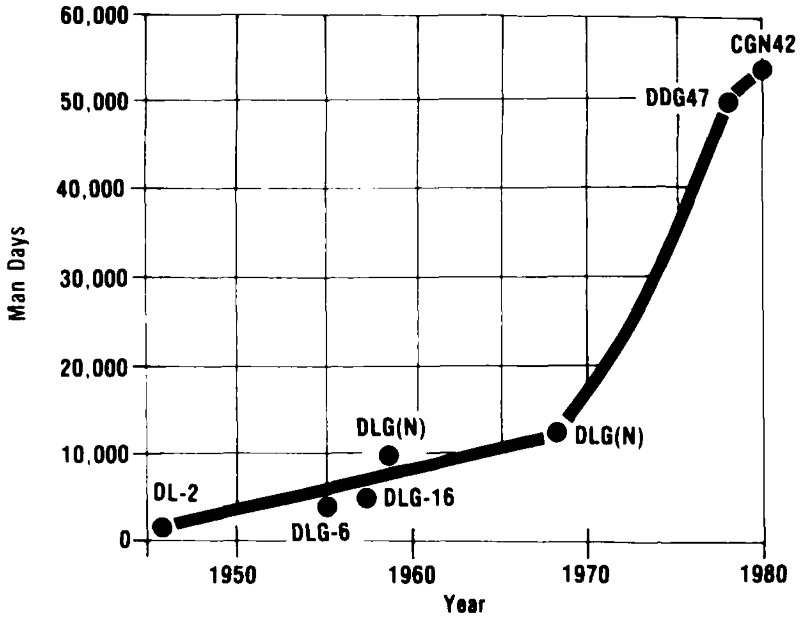
Figure 1. Exhibit I-1. Man Days of Effort to Perform the Contract Design of Various [illegible]



Source: "The Changing Nature of the U.S. Navy Ship Design Process," Robert S. Johnson (1980). Course Material from the Navy Ship Design Process Course, The Catholic University of America.

to concurrent testing in the DOD guidance is fairly specific in the resources necessary to conduct concurrent testing. Carlucci Initiative Number 12 emphasizes the requirement to fund the test resources early in the program in order to have the flexibility in the schedule to plan concurrent DT&E and OT&E. The new guidance is allowing the program managers to plan for funding of the test resources necessary for concurrent testing in order to reduce the extended acquisition cycles that have been a concern for the past several years. Visibility of program planning and strategy formulation at high levels in the DOD are requiring program managers to do risk analysis on their programs to ensure that consequences of planning concurrency in test and evaluation are considered.

Streamlining

Streamlining has its foundation in Carlucci Initiative Number 14, "Reduce the number of DOD Directives, and eliminate non-cost-effective contract requirements."[12] While this initiative is specific in nature toward the DOD Directives, it was not clear toward the direction it was to take in contract requirements. In a series of memoranda from December 1984 to June 1985, Deputy Secretary of Defense William H. Taft IV took the lead in identifying the problem and giving direction to the military services to eliminate non-cost-effective contract requirements, to which the term streamlining has been applied.[13] The thrust of his effort was to reduce layering of specifications and standards in the acquisition process, reduce the "how-to" direction in DOD requests for proposals and contractor oversight, and encourage use of non-development items (NDI), those commercially available systems from the United States or off-shore that have adequate performance to meet DOD requirements.

Momentum toward streamlining is growing. It is a natural for a program manager because effects of the initiative reduce cost and can improve schedule. However, the "not-invented-here" syndrome and the rice-bowl mentality are potential obstacles to be dealt with in building support for utilization of streamlining, the essential ingredient for which is an attitude shift by government heirachy to agree with effects of streamlining a program.[14] There is strong leadership for streamlining. Initially, there were three Naval aviation acquisitions to be scrutinized for streamlining implementation. Several others have been added and now there is a Specification Control Advocate General within the office of the Secretary of the Navy through which all large acquisitions must pass and gain concurrence for approval.

Most programs managers have taken a personal initiative because of potential cost savings and schedule improvements.

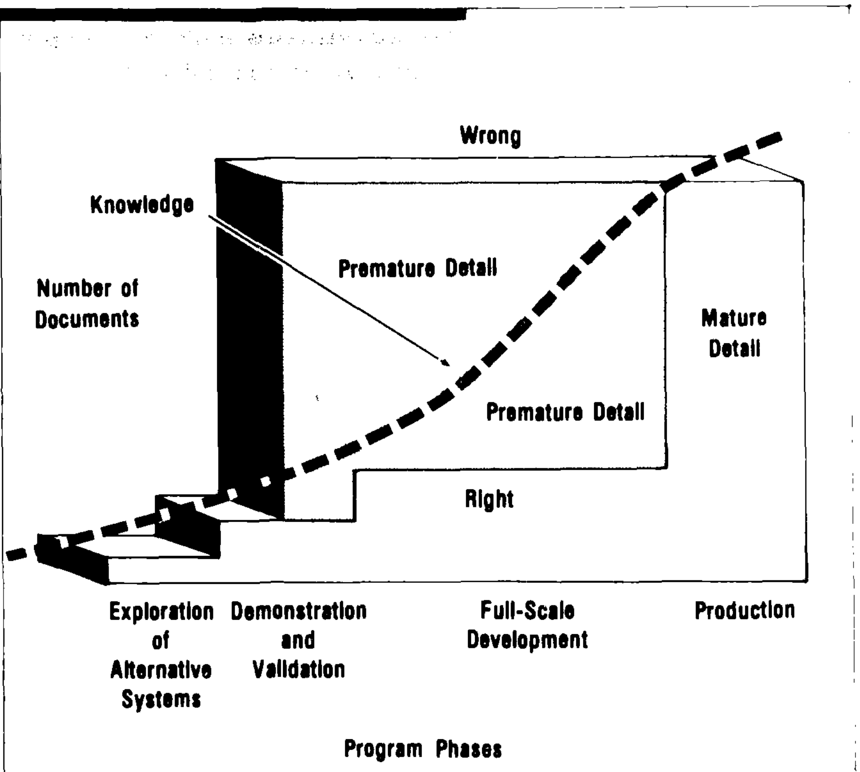
Recently, a DOD directive has implemented the streamlining initiative. However, it has been utilized in various draft forms from the beginning of Mr. Taft's memorandums. In the current DOD Directive 5000.43, the definition of streamlining is:

> Aquisition Streamlining. Any action that results in more efficient and effective use of resources to develop, produce, and deploy quality defense systems and products. This includes ensuring that only cost-effective requirements are included, at the most appropriate time, in system and equipment solicitation and contracts.[15]

The directive requires specifying contract requirements in terms of the results desired, rather than "how-to-design" or "how-to-manage," precluding premature application of design solutions, specifications, and standards. In essence, it is mandatory to tailor contract requirements to unique circumstances of individual acquisition programs, and limit contractual applicability of referenced documents to those that are essential.

Figure 2 shows the proper evolution of technical requirements through the acquisition phases.[16] In the early phases, there should be few predetermined detail designs and limitations on the development of alternatives. Only when each phase brings into focus the design that optimally provides the solution to the requirements should technical design be allowed to be directed; this primarily enhances configuration control as the design proceeds to maturity. From another perspective, there has been a tendency to

reference specifications and standards which, in turn, reference other specifications and standards in a pyramiding effect. Streamlining is aimed at reducing this pyramid. In the U.S. Navy programming documentation, two layers of specifications and standards are the maximum that can be imposed before production.



Because of its recent application, the impact on the test and evaluation phase of acquisition by streamlining's reduction of specification references has not been realized. The programs targeted for streamlining have gone through the reduction in specification tiering but have not reached the testing phase. From the tested perspective, there will be little difference except where facets of testing have been deleted from the test program because of similarity with other end-items or risk of test elimination is low. It is apparent that the tester will have to participate earlier in the development to understand design concepts and requirements in order to develop adequate test plans because reliance on previous methods of test may no longer be applicable.[17] It appears that streamlining may provide an impetus to the further incorporation of concurrency in tests as program managers trade-off cost of more resources to reduce schedule in the testing phase of acquisition programs. This is obviously a form of streamlining. Important in the decisions to streamline and or increase concurrency in a program is the increase in risk.

Risk Assessment

There is little literature providing guidance to the program manager on how to make risk assessments or how to do trade-off studies for the effects of concurrency and streamlining. In September 1982, a U.S. Navy study developed a risk-taking analysis and methodology as applied to risk associated with concurrency.[18] More recently, a Department of Defense Guide, *The Transition to Production*, describes templates regarding transition from development to production in which the test and evaluation process is amplified as a risk-taking concern for a program manager. The U.S. Navy established a course to implement the streamlining initiative and risk analysis is stressed.

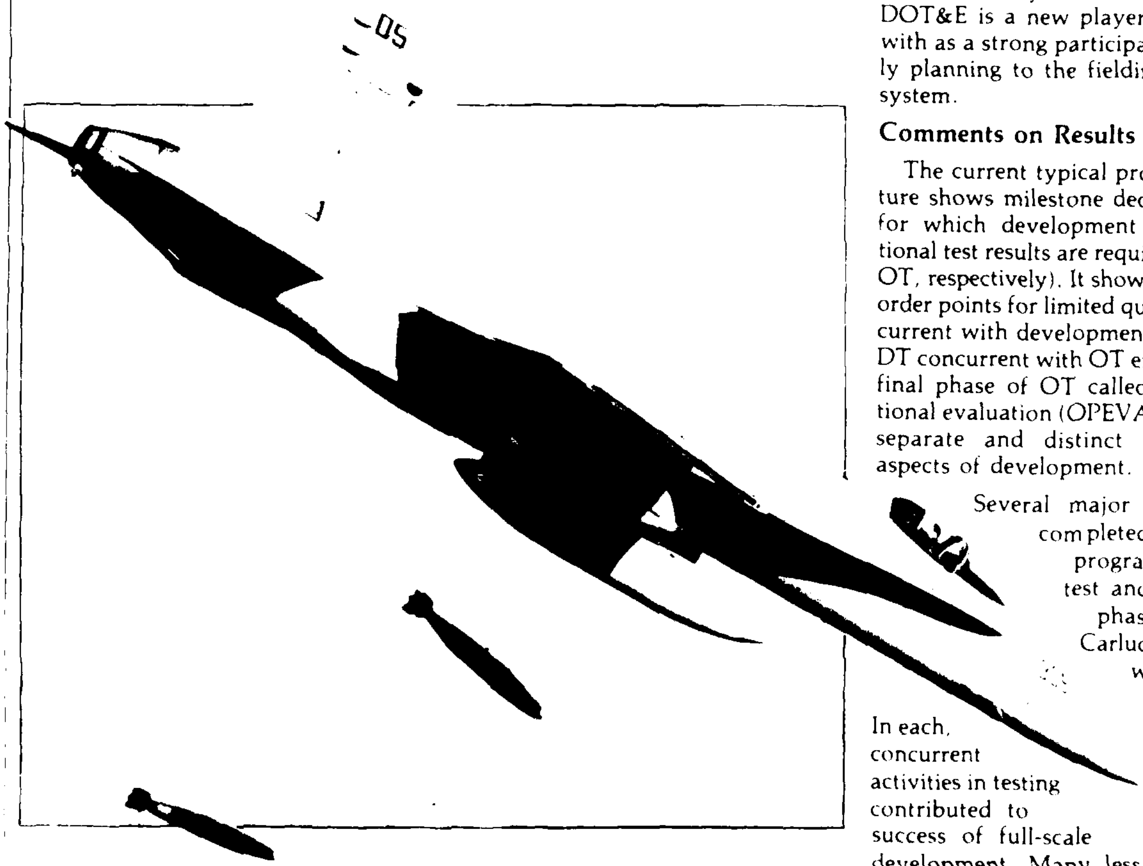
In order to make an assessment of risks associated with concurrency or streamlining, there must be a willingness to accept consequences of taking a risk, most often manifested by an increase in near-term costs to shorten the schedule.[19] In the early planning of an acquisition, a baseline is established within a given minimum of people, facilities and funds. In simple terms, the program manager adds funds to increase people and facilities applied to the acquisition which, in turn, allows the program to have concurrent activities and reduce how-to directions to the contractors, thereby shortening the schedule.

Many questions must be answered by the program manager in the planning phase. Is the system mature enough to impose specifications and standards without losing a better solution? Have I enough information to streamline testing requirements? Are risks low enough to impose concurrency of test and evaluation?

The risk must be low so that a test result will not defeat fielding of the system on time. The Defense Science Board noted that programs are not cancelled for reasons of concurrency but, rather, for technical or political reasons or because requirements change.[20]

To look at deviation from a baseline, which is considered to contain optimum contributions of cost, schedule and performance, the program manager must have the ability and willingness to accept a non-zero chance of missing the funding level or time estimate. For example, if a program has a 40-month baseline with a 10 percent chance of missing schedule, additional funds can provide test resources to support test concurrency and test requirements streamlining and maintain the same risk level. Alternatively, for the same resources, the program manager can accept a higher level of risk and shorten the schedule. Figure 2 lists seven steps of the concurrency analysis model developed for the U.S. Navy.[21]

In developing the acquisition plan, the program manager spends much effort generating support for an approach to concurrency and streamlining. Once the plan is established and its execution begins, support tends to dwindle as the program proceeds. Consequently, when the schedule is



missed or there is a requirement for more funds, the program manager is alone, finding that support is lacking when it was there in the beginning.[22] Moreover, there are significant hurdles inhibiting application of concurrency in test, hurdles arising as the program moves through its acquisition cycle.

The first and foremost of these potential conflicts with implementation of streamlining and concurrency is the importance of test and feedback of test deficiencies to the design group for analysis and correction. In subsystem design, significant strides have been taken to improve the test process. In reliability testing, there is a process called test, analyze, and fix (TAAF), which takes the time to test at accelerated rates to determine weaknesses in the design and manufacturing of procedures to improve reliability of a subsystem. This process also should occur in the full system test phase, but there the complexity of the system requires significant increases in resources for each iteration of the TAAF loop.[23] Computer-driven simulations and stimulations reduce the risk of limited resources for full system test, but there are design deficiencies arising from full-system test requiring redesign and, subsequently, affect the schedule and cost.

Another factor important to risk taking associated with concurrency and streamlining is the independence of the operational test, and the establishment of the Office of the Director, Operational Test and Evaluation (DOT&E), within the Department of Defense, reporting to the Secretary of Defense and the Congress. This director's office has oversight of military services' operational test for selected programs. Operational realism in operational test with engineering development models built in full-scale development is creating higher risk than previous approaches to concurrency of test. In summary, DOT&E is a new player to be dealt with as a strong participant from early planning to the fielding of a new system.

Comments on Results to Date

The current typical program structure shows milestone decision points for which development and operational test results are required (DT and OT, respectively). It shows production order points for limited quantities concurrent with development and shows DT concurrent with OT except for the final phase of OT called the operational evaluation (OPEVAL), which is separate and distinct from other aspects of development.

Several major acquisitions completed prescribed program structure test and evaluation phases since the Carlucci Initiatives were promulgated. In each, concurrent activities in testing contributed to success of full-scale development. Many less-than-major acquisitions completing the test phase under these initiatives are achieving some success in compacting schedule as a result of concurrency of testing or another aspect of the acquisition cycle.

The F/A-18 Hornet was the first full system development that was principal sited at a single location by the U.S. Navy for the majority of the flight test, in this case NATC, Patuxent River, Md. Rationale for the principal siting was reduction in duplication of resources and collection of a single set of data by the contractor and the U.S. Navy. In the Hornet's case operational testers were co-located at NATC for case, initial operational test and evaluation, providing an opportunity for three types of testers to participate in data collection to support conclusions that the aircraft met require-

ments. Post test analyses generally show that the concept of principal siting was effective from aspects of resource streamlining, cost savings, and schedule compaction. Some contractors maintain that moving the aircraft away from the design and manufacturing site resulted in delays in data analysis and subsequent corrective actions. Since being fielded, the aircraft has demonstrated readiness and maintainability almost twice as good as its sister tactical aircraft. From an overall U.S. Navy perspective, the concurrency implemented in the Hornet acquisition proved successful because the system was fielded on time with quality.

The AV-8B Harrier acquisition program also was principal sited at NATC to achieve the same economics of cost and schedule. The concept was to take the existing Harrier engine and design a new airframe and weapon system around the engine. As the program moved through full-scale test, the engine did not perform as predicted. With cooperation of the test force, operational testing was divided into two phases, giving the program manager time to fix engine performance before the final phase of operational testing. Without concurrency of operational testing and prior schedule compaction, it would have been necessary to terminate the Harrier test phase until engine performance was improved at an increase of $100 million. Significant risk was assumed with this approach had the engine performance not improved in time to start the second phase of operational testing. There also was concurrency in test and limited production of the aircraft, providing field assets from a pilot production and two limited production lots. The success of this acquisition was acknowledged to the program manager by the Commander, Operational Test and Evaluation Force, who said the operational test of the AV-8B was the best for an aviation system he had experienced in his tour.[24]

A third example of concurrency in the full-scale test and evaluation phase is that achieved by the SH-60B Seahawk. The airframe is similar to the U.S. Army Blackhawk so that limited testing could be achieved without compromising the importance of test results. The main test effort focused on

Table 1. Steps in Concurrency Analysis Model Developed for U.S. Navy

Step 1

Construction Baseline Schedule

- 1.1 Develop Project Schedule Philosphy
- 1.2 Construct Baseline Networks
- 1.3 Identify Potential Concurrency Options
- 1.4 Develop Structure of Risk Evaluation Checklists

Step 2

Evaluate Funding and Schedule Constraints

- 2.1 Determine Significance of Constraints
- 2.2 Determine Scope of Concurrency
- 2.3 Relate Constraints to Concurrency Options

Step 3

Determine Motivation of Concurrency: Schedule Protection or Schedule Compression

- 3.1 Determine Extent of Internal Program Limitations
- 3.2 Refine Baseline Schedule Estimates
- 3.3 Reevaluate Preceding Decisions
- 3.4 Develop Initial Set of Risk Evaluation Checklists

Step 4

Determine Degree of Acceptable Cost Risk/ Schedule Risk

- 4.1 Develop Final Baseline Resources and Schedule Estimates
- 4.2 Determine Acceptable Degree of Concurrency
- 4.3 Determine Acceptable Degree of Risk
- 4.4 Review Remaining Concurrency Options

Step 5

Develop Alternative Schedules

- 5.1 Select Constrained Concurrency Options to be Used in Developing Alternatives
- 5.2 Group Concurrency Options for Development of Alternatives
- 5.3 Generate Alternative Schedules
- 5.4 Determine Critical Path for Each Alternative

Step 6

Evaluate Risk for Each Alternative

- 6.1 Finalize Evaluation Checklists
- 6.2 Apply Checklists to Detailed Schedule and Subschedules
- 6.3 Score Each Alternative Based on Cost and Schedule Risk and Response to Constraints
- 6.4 Aggregate Data to Decision-Making Level of Detail

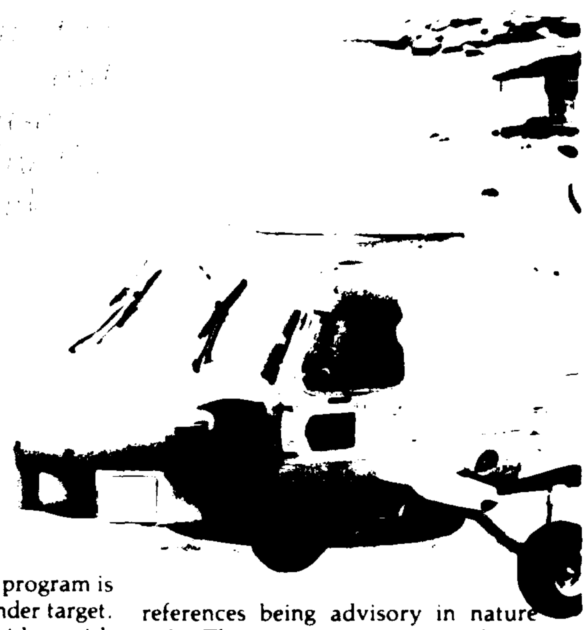
Step 7

Select New Schedule

- 7.1 Review and Revise Decision-Making Criteria
- 7.2 Review and Revise Proposed Schedule-Monitoring Techniques
- 7.3 Analyze Results of Risk Analysis of Alternatives
- 7.4 Apply Decision-Making Criteria to Viable Alternatives
- 7.5 Select Alternatives
- 7.6 Revise Existing Schedule

the total mission systems, both the aircraft and ship connected together by a data link in an anti-ship and anti-submarine suite. Again, principal site of testing was NATC for the avionics suite integration efforts of the contractor. The utilization of the NATC resources maximized savings in schedule and cost of testing. Co-location of the operational test squadron at NATC provided a unique opportunity for concurrent testing.

In each of these full system test and evaluation phases there was risk associated with the concurrency and streamlining efforts that preceeded the testing. However, risks were minimized by program managers and considerable savings were achieved by trade-offs made from the original baseline for the programs.



The Future

Many initiatives set into motion by Mr. Carlucci have taken root and are implemented. As demonstrated by the F/A-18 Hornet, AV-8B Harrier and SH-60B Seahawk, concurrency in the test and evaluation phase of full-scale development is improving schedule, or providing relief to correct deficiencies found in testing. The full effect of specification streamlining on the test and evaluation phase has not been determined. Every program manager is implementing the initiative but few systems have had time to reach the test and evaluation phase. However, one program underwent its streamlining in 1985 due to a cost cap imposed on the program by the Secretary of the Navy. The consequence of this streamlining effort is shown in Table 2.[25]

The T-45 Undergraduate Jet Flight Training System was initially baselined at about $728 million. The Secretary of the Navy set a cap at $450 million after which the program manager and team, including contractor, scrubbed various program components to eliminate cost. The result is shown in the right column of Table 2.[26] Final cost of the current development program is $438 million, $12 million under target. Reduction in cost was not without risk in that two test articles will limit the time available to correct deficiencies, reduce potential for concurrent test activities, and reduce scope of testing during the test and evaluation phase. However, the aircraft is a modification of an aircraft already in use by the British and, therefore, has a significant amount of test data available which can be translated across to the U.S. carrier-based version. A major part is the training support system that goes with the aircraft, a new concept in the fielding of a training system. Testing of this support system will be new for the contractor and for the U.S. Navy. In the case of this system, the operator is the training command—a newcomer to the test and evaluation phase of acquisition.

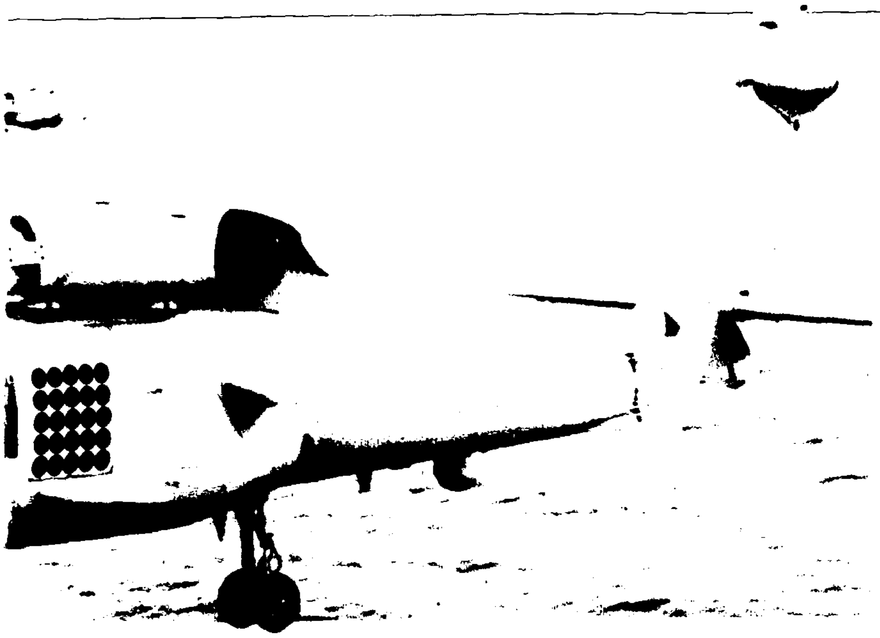
The V-22 Osprey acquisition program has reduced references to specifications and standards by an equivalent of $350 million. References to specifications and standards are limited to two tiers with further references being advisory in nature only. The program manager, realizing he was taking a significant risk, required the contractor to fix deficiencies found in development testing of a given severity, and to fix critical and major deficiencies found in operational test at no additional cost to the government. In addition, the government is participating in every aspect of the full-scale development and has military test pilots participating in the flight test data collection effort, starting after the first 25 flight hours have been accumulated. Thus, risk was taken by streamlining but further steps were taken to reduce risk to the government that could occur from the contractor building to a performance specification and a limited detailed specification.[27]

In another program, as a consequence of streamlining, the government has imposed strict performance, warranty, and reliability contractional clauses to further protect government interests. Comprehensive test and evaluation will be, therefore, a critical element in determining compliance with these contractural clauses. As written in requests for proposals, failure to meet specified parameters in these specific clauses will result in futher design, development, and test tasks on the part of the contractor at his own expense.[28]

Initial efforts at concurrency and streamlining are having a positive effect on major programs so far as initiatives are implemented. Risks are be-

Table 2. Development Program Comparison

	BEFORE	AFTER
FSED CONTRACT TYPE	**CPIF**	**FFP**
GROUND TEST ARTICLES	**3**	**2**
FLIGHT TEST AIRCRAFT	**4**	**2**
FLIGHT TEST HOURS	**913**	**701**
DATA REQUIREMENTS	**530**	**251**
SPECIFICATIONS	**322**	**281**



ing taken by program managers that are methodically determined through trade-off analyses. There are concerns that risks may not be supported by their advocates when these risks result in a schedule slip, a performance limitation, or a cost overrun. The program manager is the responsible individual for implementing initiatives and must bear the burden of failure to meet the triple constraint of cost, schedule and performance even though he is executing policy and guidance set by higher authority. There is need for a tying policy that provides an audit trail to those who required the program manager to execute policy that looked good in the planning but proved to be higher risk that was predicted in meeting requirements of the triple constraint.

Summary

History shows Post-WW II concurrent test and production at one apex, and 1970s fly-before-buy at another. As a result of two Carlucci Initiatives, manifested in concurrency and streamlining, we are moving toward more concurrency, particularly in test and evaluation. Streamlining is being implemented in all programs but, as of this writing, there has not been a program going through the full acquisition test and evaluation phase that has been streamlined from its initiation.

Both initiatives have brought savings in cost and abbreviated schedule. There is concern, however, that support infrastructure which required execution of the initiatives may not be in place when the program does not meet its cost schedule or performance requirements. ■

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INSIDE DSMC

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JOCG

INSENSITIVE MUNITIONS

A New Dimension of System Performance

Gary H. Parsons
Captain Mark J. Surina, USAF

The need for insensitive munitions, which do not react adversely to unplanned stimuli, is growing and vital to the safety and readiness of forward-based forces. Weapon terminal effects, as well as integrated system performance, are standards that drive conventional weapon development. A new DOD subgroup was created to monitor and coordinate the military services' Insensitive Munitons (IM) programs. The Joint Ordnance Commanders Group (JOCG) endorsed the IM Subgroup in June 1986. This new area of joint review has the potential to facilitate interservice technology sharing, reduce duplication of effort, and accrue savings to the United States by fostering weapon commonality and compatibility. The IMs have the potential to satisfy performance and cost requirements and add a new safety dimension.

Genesis of Interest in Insensitive Munitions

The Vietnam conflict provided impetus for Insensitive Munitions. Damage caused by our munitions exploding because of fire, handling errors, or nearby hostile fire far exceeded damage to air bases and ships caused by enemy weapons. Accidents with nuclear warheads in the late 1950s at Thule, Greenland, and Palomar, Spain, and the growing threat of terrorist activity forced the Department of Energy to seek new conventional explosives that would not disperse radioactive products in any foreseeable nuclear weapon accident.

Traditional emphasis of weapons development before such incidents was on classic measures of performance, cost, and safety. Growth of interest in IMs resulted from a realization that total system effectiveness improves dramatically if our munitions are less vulnerable to enemy attack. Effectiveness improvement arises when munitions meet safety standards so they can be transported and stored in places where operational readiness is greatly improved; for instance, close to aircraft hangars, on ships, or on armored personnel carriers. The DOD is responding to this realization by developing munitions that react mildly to threats that historically cause the greatest problems.

The insensitivity requirement is not a radical departure from past development. It is a shift in emphasis from munition performance, probability-of-kill, to performance of the total weapon system, whether that system includes aircraft carrier, air base, or armored division. The system's entire environment is a concern. Technology emphasis is on design of munitions and explosives that make munitions less likely to respond adversely to accident or enemy attack.

There are two related concerns in the development of insensitive munitions. First, the differing threats and environments of each military service might result in service-unique criteria for insensitivity. In that case, munitions intended for joint-use would be rejected by one or more military services as not meeting their criteria, leading to duplication of research and development and acquisition efforts, which is the second concern. Military services might duplicate Insensitive Munitions technology in search of solutions to common problems. The precedent for this concern is the different explosive fills already used by the Army, Navy, and Air Force for general-purpose munitions. There is a solution. A steering group, if composed of multiservice representatives with the support of their commanders, can direct, monitor and assist in an integrated Department of Defense effort to develop insensitive munitions. The structure to administer the group already exists—the Joint Ordnance Commanders Group.

Function and Structure of Joint Ordnance Commanders Group

The Joint Ordnance Commanders Group consists of flag officers from all four military services, each representing the highest level of command in conventional munitions development and production. Its mission is to review and coordinate interservice activities, facilitate technology interchange, foster joint-service development, and improve production readiness. Established in September 1984 and formally chartered in June 1985, the JOCG replaced the Joint Technical Coordinating Group which had, for more than 15 years, coordinated the military services' research and development at a lower management level.

A full-time Executive Committee, again representing all military services, administers JOCG functions and monitors progress of two dozen subgroups on tasks assigned by the JOCG. Subgroups comprise ordnance development activities including research and development, quality assurance, data management, program transition, maintenance, and disposal.

In February 1986, the JOCG reviewed military services' efforts to develop insensitive munitions and directed that a new subgroup be formed to coordinate that area. The requirement to form a JOCG Insensitive Munitions subgroup derived from a new service policy formulated by the Vice Chiefs of Staff in their capacity as the Joint Requirements Oversight Council.

Insensitive Munitions Policy

The reactive nature of munitions increases their susceptibility to unplanned stimuli, presenting a major threat to survivability of our ships, air-

craft, weapons carriers, tanks, other weapons platforms, and stockpiles. This threat can be reduced by making munitions insensitive through the use of insensitive materials or improved mechanical/electrical design concepts.

To the extent practical, all munitions should be made to meet the criteria for Insensitive Munitions. Practical constraints include but are not limited to performance requirements, affordability, remaining service life, and technical feasibility.

Each service will conduct an assessment of its existing and planned munitions for incorporation of insensitive energetic materials and/or insensitive mechanical electrical designs. After assessment, those munitions required to be insensitive should meet specific test criteria.

—All programmatic milestone reviews for munitions will specifically address sensitivity issue including cost, impact on operational capability, and alternatives.

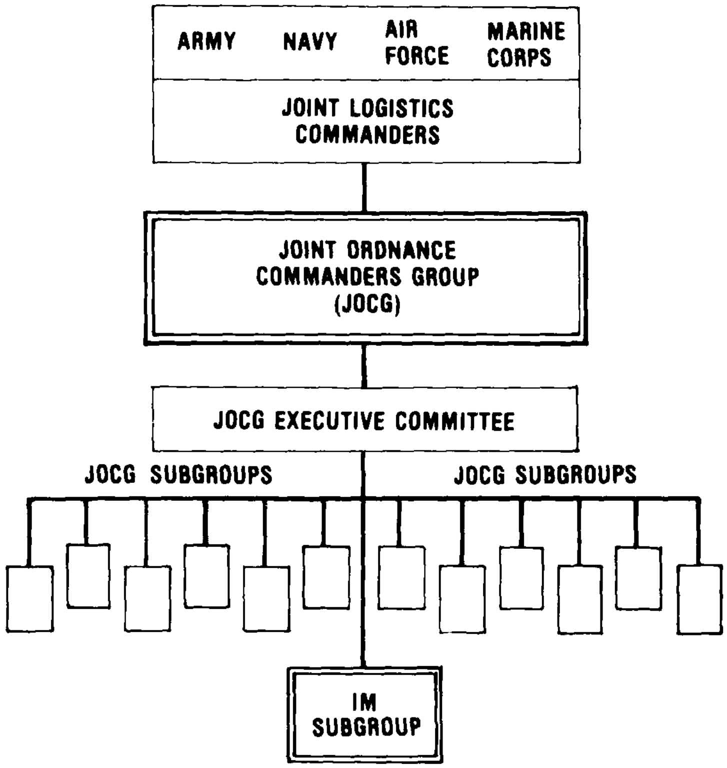
—Operational capability must be maintained, but every effort must be made to meet operational requirements with the least sensitive system design available.

—If a munition cannot be designed to be insensitive, it will be designed to be less sensitive through incorporation of as many insensitive features as the design service considers to be appropriate and feasible.

The Joint Logistics Commanders will review the status of IM annually. The status will include a report of munitions that will be made insensitive, those that can be made to meet some IM criteria, and those that cannot meet any IM criteria. The report will include plans and unresolved issues. The Joint Logistics Commanders will initiate appropriate changes to this requirement and the criteria based on their annual review. Changes will reflect additional requirements and criteria that are common among the military services and will improve the insensitivity of munitions. This policy is being coordinated through the military services, for signature by the Service Secretaries.

A special organization was set up under the Joint Ordnance Commanders, the IM Subgroup, to ensure that the military services develop weapons to meet commonly accepted sensitivity criteria, and foster technology exchange through interservice technical reviews and reports.

Figure 1. Structure of JOCG and Subgroups



Insensitive Munitions Subgroup

A charter for the new subgroup was approved in June 1986. Members are from the Air Force (both Logistics and Systems Command), Naval Air and Sea Systems Command, Army Armament Development and Missile Commands, and Marines Logistic Command. Five tasks were assigned by JOCG and reporting and management review process was established.

Insensitive Munitions Subgroup Tasks

—Task 1. Review services' Insensitive Munitions technology and development programs before POM submissions or system development.

—Task 2. Recommend joint-service Insensitive Munitions programs.

—Task 3. Review status of Insensitive Munitions annually. Status will include report of munitions to be made insensitive, those that can meet some Insensitive Munitions criteria, and those that cannot meet any Insensitive Munitions criteria. The report will include plans and unresolved issues. The military services will prepare appropriate changes to the Joint Requirement for Insensitive Munitions. The report will be presented at the Joint Requirement Oversight Council via the Joint Logistics Commanders.

—Task 4. Develop test procedures and pass/fail criteria for areas identified "To Be Determined" in the Joint Service Technical Criteria and Definitions for Insensitive Munitions.

—Task 5. Coordinate, as necessary, with other JOCG development subgroups.

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[illegible]

Fragment Impact	**To Be Determined**	**To Be Determined**
Shaped Charge Jet	**To Be Determined**	**To Be Determined**
Spall	**To Be Determined**	**To Be Determined**
Electromagnetic Pulse	**Assessment**	**To Be Determined**
Electrostatic	**Assessment**	**To Be Determined**

Insensitive High-Explosive Ammunition

The Department of Defense Explosive Safety Boad (DDESB) is responsible for hazard classification of munitions. It was the first organization to establish test criteria that could be used to categorize munitions into a new hazard classification they call Insensitive High Explosive (IHE) ammunition. The IHEs are at the end of the spectrum ranging from mass-propagating detonation (designated 1.1) to insensitive (1.5).

Three series of tests are called for under DOD-Standard 6055.9 for IHE ammunition. The first two describe response of energetic material to laboratory and generic field tests. The final series evaluates the system in fast and slow cookoff, bullet and sled impact, and sympathetic detonation tests. When these tests are successfully passed, a hazard classification of 1.5 may be assigned; as a consequence, a new set of storage guidelines may be applied to the ammunition. Storage guidelines for 1.5 munitions are less stringent than 1.1 in their need for large separation between storage areas and vulnerable buildings or aircraft.

We have succeeded in reaching commonality in what the military services feel are critical tests for insensitive munitions. We are certain which tests are required by the Department of Defense Explosive Safety Board to classify Insensitive High Explosive ammunition. Service-common tests include fast cookoff, multiple bullet impact, and sympathetic detonation. This important step ties together reduced vulnerability and simplified storage, handling and transportation. The 6055.9 criteria have not been accepted by the North Atlantic Treaty Organization although it has been asked by DDESB to review and comment on test methods and pass/fail criteria.

Implications for Program Managers

The development community is in the throes of adopting and adjusting to a new requirement that places munition sensitivity on equal footing with other requirements. Insensitivity seems destined to join cost, schedule and performance as a classic measure of a munition system's success. If successful, the IM Subgroup should not be needed once the military services reach agreement on a common definition for insensitive munitions. When that occurs, a Department of Defense standard can be written and included in program direction as a "must-comply" specification for weapon development. The technology base for insensitive munitions exists within subgroups for explosives, propellants, fuzing, and warhead design. When a common standard is adopted, there will no longer be a need for an IM subgroup to coordinate research and development.

To succeed in fielding these new Insensitive Munitions, the following four conditions must be satisfied: jointly accepted policy, jointly accepted requirements, source of technology from which to draw cost-effective solutions, an enforcing body to ensure requirements are met. Significant progress in these four areas has occurred. The policy is in place. Requirements are being developed by the IM Subgroup and its special committees. The technology base is being developed in the laboratory and field and coordinated by Joint Ordnance Commanders Group specialty subgroups. Enforcing activities are the service safety review boards and the Department of Defense Explosive Safety Board.

Summary

There is potential for interservice cooperation and joint-development programs facilitated by the IM Subgroup. Interest is high and has the endorsement of upper management in each military service. Members of the newly created IM Subgroup are correctly working toward obsolescence. Examine your development program. The question is: "How can I design my product to react mildly and in a controlled manner to threats experienced during its life cycle?" ■

Center Improves Fuel Tank

A low-profile fuel tank, developed by the U.S. Army Troop Support Command's Belvoir Research, Development and Engineering Center, is undergoing performance and endurance testing at Aberdeen Proving Ground, Md. A redesign of the existing 600-gallon fuel tank, its profile has been lowered 11 inches, allowing this tank to be transported in a C-130 aircraft while mounted on a 5-ton cargo truck. This change provides air readiness fuel capability during emergency situations.

The tank supplies aviation fuel, diesel and gasoline to aircraft, mobile ground vehicles and other equipment in tactical areas. ■

DSMC [illegible]

Publications Available

Two more publications of the Defense Systems Management College will soon be available through Government Printing Office outlets. The *Glossary of Acquisition Management Acronyms and Terms*, stock number 008-020-01119-3, costs $6.00; the *Warranty Handbook*, stock number 008-020-01120-7, costs $5.50.

Send prepayment to Superintendent of Documents, Washington, DC 20402-9325. When ordering, refer to both title and stock number. To order with Visa or MasterCard, phone (202) 783-3238. ■

"Forewarned, forearmed; to be prepared is half the victory."

Cervantes

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